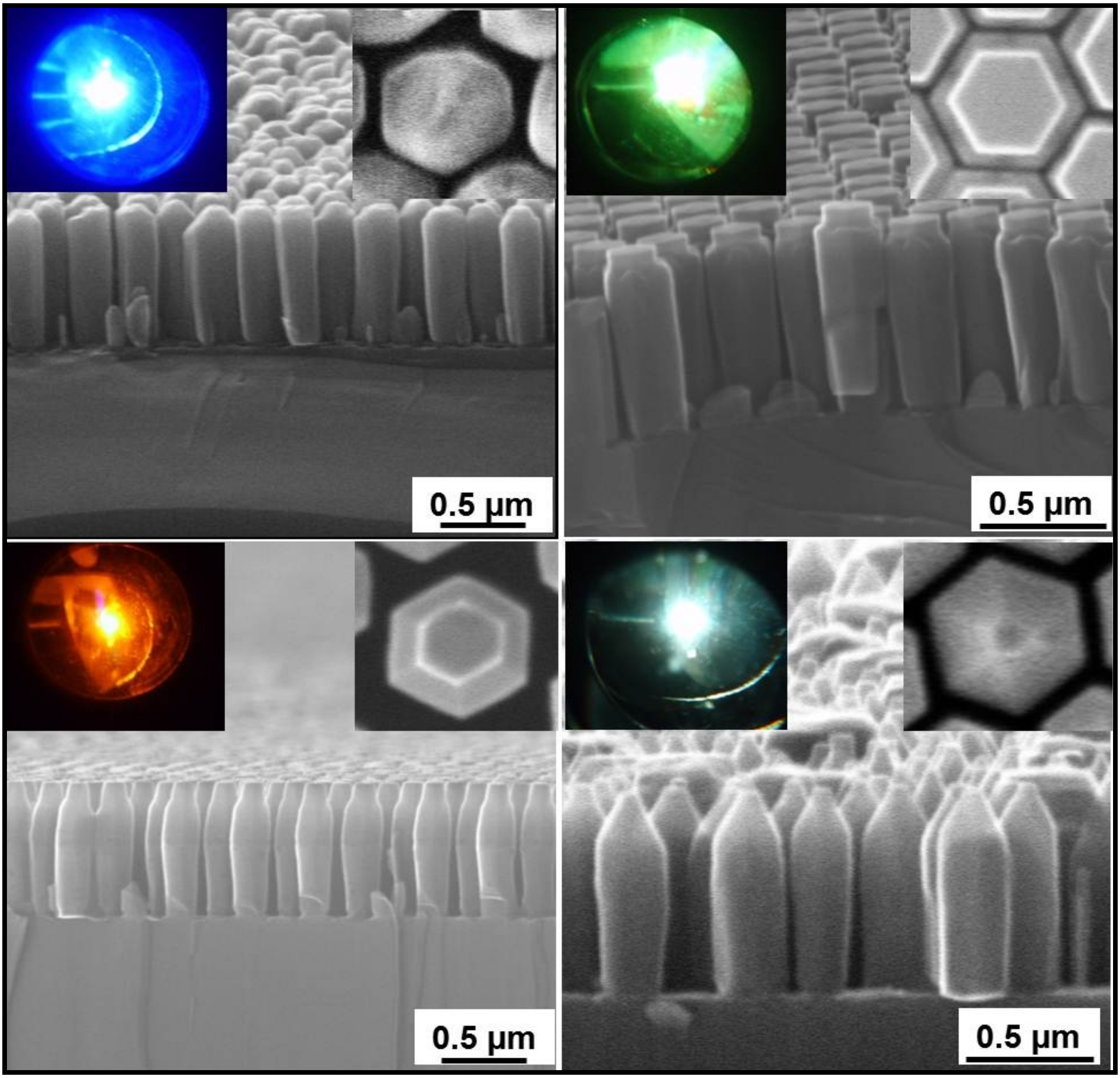
Instituto de Sistemas Optoelectrónicos y Microtecnología

Institute of Optoelectronics Systems and Microtechnology

ACTIVITY REPORT (2010 - 2014)



UNIVERSIDAD POLITÉCNICA DE MADRID

Instituto de Sistemas Optotelectrónicos y Microtecnología

(INSTITUTE OF OPTOELECTRONICS SYSTEMS AND MICROTECHNOLOGY)

Universidad Politécnica de Madrid

Activity Report

2010-2014

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MBE Selective Area Growth of InGaN/GaN nanocolumns (NCs) with corresponding PL emission pictures. From left to right: blue emission from InGaN NCs with 18% In content, green emission from InGaN NCs with 30% In content, red/orange emission from InGaN NCs with 38% In content and finally, white light emission from NCs grown with three different InGaN sections with similar In contents as the first three photographs (combination of the red-green-blue emission).

PREFACE


The Institute of Optoelectronics Systems and Microtechnology (ISOM) is devoted to research and development activities in information and communication technologies based on III-V semiconductors, grapheme, magnetic and non-metallic materials. This report summarizes the technical and scientific activities carried out at ISOM in the period 2010-2014 in several areas where knowledge, experience, and technology have been enlarged. ISOM has now three main groups devoted to Semiconductor Devices, Magnetic Devices, and Non-metallic Simulation. New staff members joined ISOM during this period, establishing new research lines and reinforcing the already existing ones. During this period, research on nanoscience and nanotechnology has boosted in the areas of semiconductor and magnetic materials and devices, as well as a new research lines devoted to Graphene, Photovoltaics, Single Photon Sources, NanoLEDs, Biosensors, and Magnetic Nanoparticles which are a few examples of the research activities at ISOM.

In 2009 UPM launched a very ambitious initiative, called Nanotech, aiming to promote activities in the nano area. A relevant part of this initiative is the “ISAAC PERAL” program, an Industry-Academia BBVA Foundation-UPM international Chair, within the Marie Curie Action co-fund (FP7) that provided a position for a Senior Researcher to boost activities in Nano-photovoltaics and Nanosensors. This position was accompanied by a full package of research funding and human resources that integrated within ISOM making use of its available facilities and infrastructures and promoting active cooperation with the already existing research teams.

During this period new equipments have been incorporated to ISOM: a Plasma enhanced CVD system to produce graphene films, a FESEM microscope with spatially resolved cathodoluminescence, an Inductively Coupled Plasma (ICP) dry etcher, and a Chemical Beam Epitaxy (CBE) system devoted to III-Nitride nanostructures and films grown on silicon substrates. These new tools will reinforce the ISOM capabilities in several areas.

Research on semiconductor materials and devices at ISOM has been largely based on binary and alloy compounds containing nitrogen (group-III nitrides), leading to either wide or narrow band-gap heterostructures. Progress in optical detectors based on nitride Quantum Dots (QDs) and Quantum Wells (QWs), Single Photon Sources for quantum computing, nanoemitters (LED), IR detectors working close to room temperature, surface acoustic wave devices, MEMS and NEMS (nanoresonators, RF-switches), high temperature electronics, and in understanding the surface physico-chemical properties of AlGaN/GaN transistors, has continued during this period.

Four research lines launched in 2009, related to semiconductor materials, have continued progressing during this period: 1) ZnO (films and nanorods) for UV solar radiation monitoring and imaging systems; 2) Integrated Optical Micro and Nanosystems (optical biosensors integrated in a chip, Lab-on-a-chip); 3) Devices for energy conversion and photovoltaics, dealing with High efficiency InGaN heterojunction (nano) Solar Cells grown by MBE, Nitride-based HEMTs and switches for efficient energy power converters, and MEMS and NEMS for energy harvesting based in nitrides and oxides; 4) Efficient, phosphor-free ordered arrays of nano-LEDs for white light generation, based on III-nitrides grown by MBE on nanopatterned silicon substrates. In addition, another two lines of research have been launched during this period, namely: 5) Graphene growth and applications and 6) QD and Nanorod Nitride-based biosensors and water splitting systems (hydrogen generation). In the area of magnetic materials, research focused on magnetic sensors and devices, Spintronics and magnetic nanoparticles for biomedical applications. Activities on simulation focused on non-metallic materials and complex fluids, molecular dynamics methodology and advanced Monte Carlo techniques, adsorption and nanostructured materials, "single-molecule" sensors for biomolecules (proteins, toxins), and jammed structures and glassy materials.

The research period covered by this report shows a significant participation of ISOM in European Union research programs, in both the VII Framework Program and through the European Defence Agency. A new line of research on smart and efficient white lighting initiated in 2009 as a participation in an EU FP7 project coordinated by OSRAM (Germany) was followed by another project in a similar area coordinated by the Technical University of Braunschweig (Germany).

As summarized in this report, ISOM significantly participated in national and regional research programs. Rapid developments in information, communication and nanotechnologies moved us to seek and to develop participation in frontier research areas, as nanotechnology, biosensors and MEMS. ISOM cooperation with Spanish industries and Institutions has been reinforced in this period. It is particularly worthed to remark its recent cooperations with ABENGOA, in the field of Photovoltaics, and with REPSOL developing applications of graphene in the Energy Harvesting field.

Along this period, the technology center of ISOM, as a Scientific and Technological Singular Facility (ICTS) has continued providing technological services to external academic laboratories and industry and has been selected as a node in the new map developed by the Spanish Ministry of Economy (MINECO) in 2014, running as a network with other Spanish Institutions to provide a wider range of services (see section on ICTS).

Finally, I would like to thank all ISOM's scientific staff members, Doctors, PhD students, and support personnel for their commitment and continuous efforts through these years. We acknowledge the support of the various funding Institutions for their confidence in our activities. Thanks also are given to the Electronic Engineering, Applied Physics and Chemistry Departments, to the ETSIT and ETSII Directors, the Moncloa Campus of Excellence, and to the UPM Rector for their continuous support and understanding.

Madrid, May 2015

Enrique Calleja Pardo

Director

Activity Report 2010-2014

CONTENTS

1 PRESENTATION AND OBJECTIVES

ISOM-UPM Image Gallery with some selected pictures of our Laboratories and Equipment.

The *Instituto de Sistemas Optoelectrónicos y Microtecnología* (ISOM) is an interdepartmental research Institution of *Universidad Politécnica de Madrid* (UPM). ISOM was created on March 16th 2000. ISOM technological facilities are located at the basement of the *López Araujo* building at the *Escuela Técnica Superior de Ingenieros de Telecomunicación* (ETSIT) of UPM (*Ciudad Universitaria* campus). These facilities include a 400 m^2 clean room and 300 m^2 of characterization and system development laboratories. Simulation activities of non-metallic materials are carried out at the *Escuela Técnica Superior de Ingenieros Industriales* (ETSII) of UPM (*Nuevos Ministerios* location). The Institute has presently 45 researchers, 5 Erasmus students, 4 technicians and 2 administrative assistants. Researchers from Electronics, Physics and Chemistry Departments are combining their research efforts in a truly multidepartmental and pluridisciplinar R&D Institute.

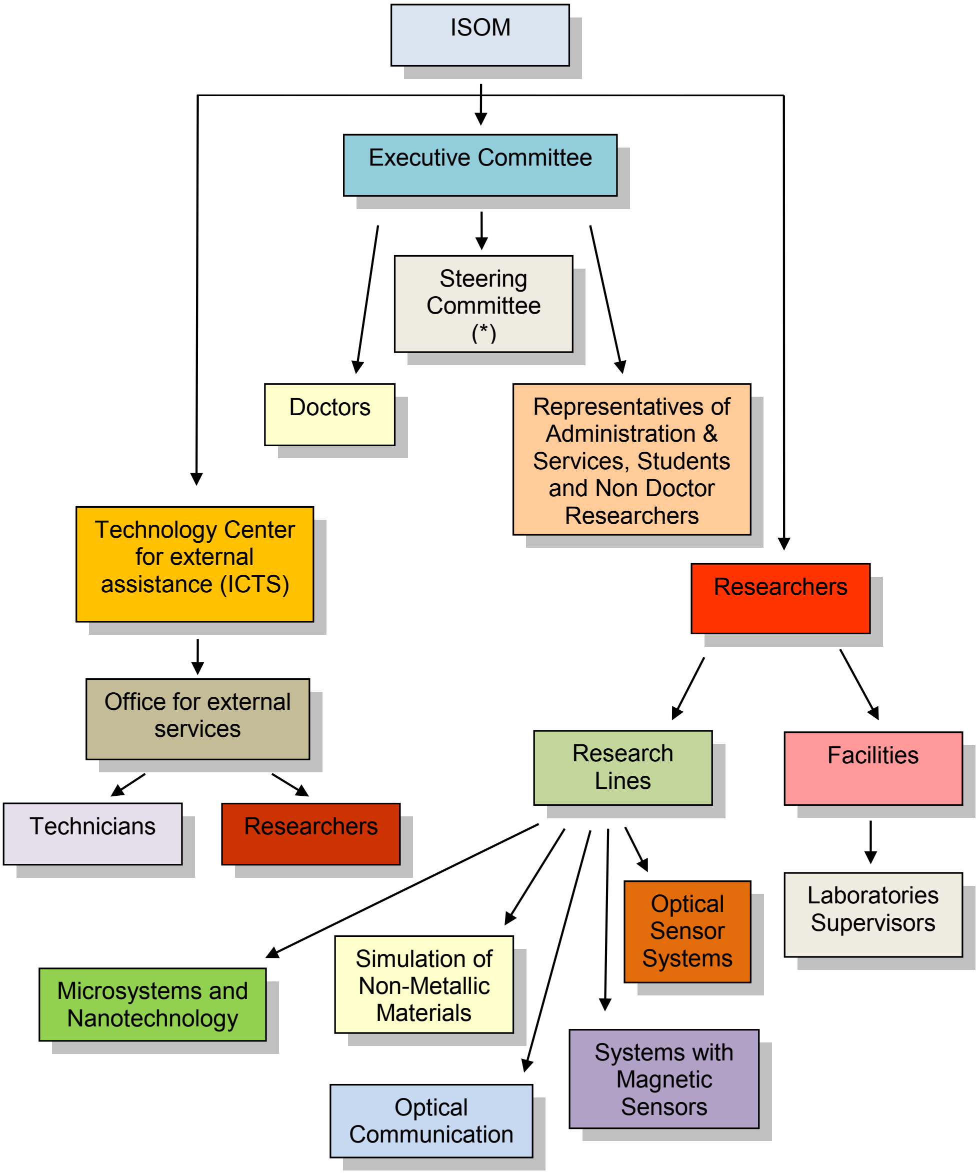
The mission of ISOM is to perform research in the fields of detection, processing, transmission and recording of information by means of micro and nanotechnologies based on the optical, electronic, magnetic and chemical properties of materials and structures. As a University Institute, education and training of innovative professionals and scientists is a first priority, to be accomplished through their participation in research and development activities seeking new knowledge, and through graduate education programs.

The Technology Centre of ISOM was awarded the recognition as a "*Scientific and Technological Singular Facility*" (ICTS) by the Spanish Ministry of Education in 2001. Through periodic public calls, ICTS-ISOM offers its services on technology, processing and characterization to the Spanish and EU scientific and technical community. ISOM is an ICTS in the new map of such facilities elaborated in 2014, working in the network “Spanish Network of Clean Rooms for Micro and Nano Fabrication” together with the Microelectronics Center (CNM-CSIC) in Barcelona and the Nanophotonics Technology Center (NTC-UPVLC) in Valencia.

The transfer of R&D results to the industry and the cooperation with external Laboratories and Institutions, are very important objectives pursued by the Institute. ISOM seeks to be a R&D laboratory able to participate and to lead research projects at the European Union and international level. ISOM aims to be a centre of excellence, a reference research laboratory, and a singular scientific and technological facility that openly provides assessment and services to other academic and non-academic entities. The Institute intends to contribute to the generation of spin-off companies by means of temporary agreements on use of clean room space and processing equipment as well as by providing its R&D expertise.

2 ORGANIZATION CHART

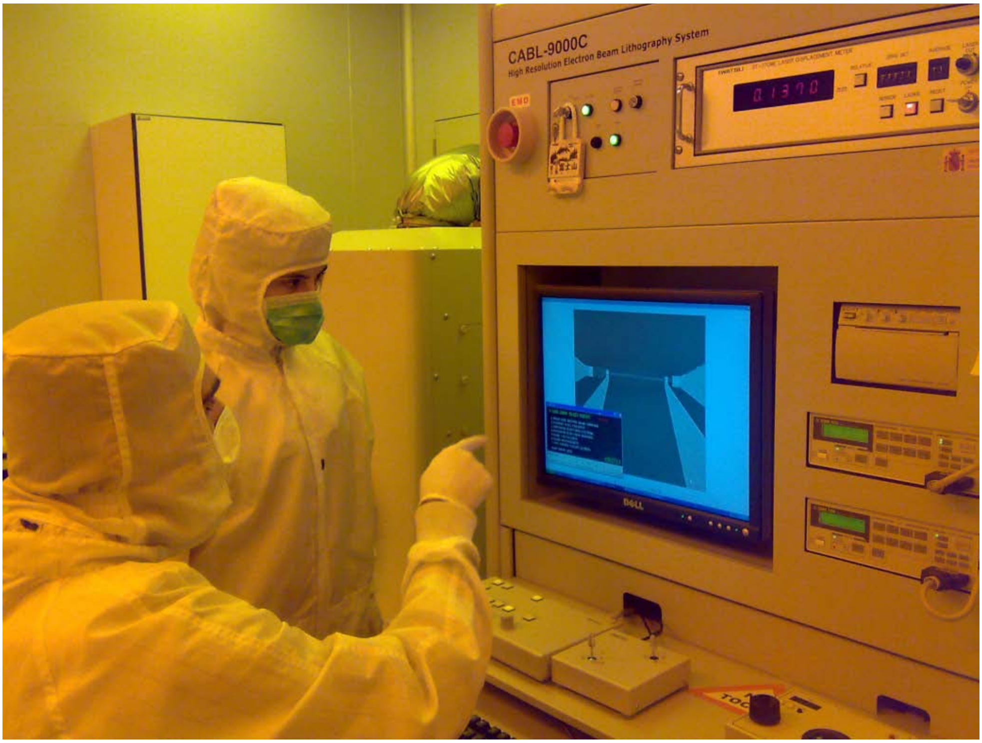
ISOM uses a number of sample holders for the connection of the devices depending on the nature of the measurement that will be performed: optical, magnetic, electrical at high or low frequency, etc. The picture shows a chip with 45 devices connected with wirebonding to a non-magnetic high frequency chip-holder.



(*) STEERING COMMITTEE:

Director:	Enrique Calleja Pardo
Vice-director:	Claudio Aroca Hernández-Ros
Secretary:	Miguel Ángel Sánchez García
Technical coordinator:	José Luis Prieto Martín
ICTS coordinator:	Javier Martínez Rodríguez

3 ICTS (SCIENTIFIC AND TECNOLOGICAL SINGULAR INFRASTRUCTURE)



Electron Beam Lithography System. This is a Crestec 9500 system characterized by its great stability in beam current and position. The minimum line width is 10 nm. Its stability allows the patterning of large areas with high reproducibility of the features. It also has a very good stitching and overlay accuracy, allowing the processing of multilayered devices on up to 4" wafers.

3.1 Description of the ICTS: "CT-ISOM"

At the end of 2001, the "Technology Center of ISOM" (CT-ISOM) was acknowledged as a Large Scientific Infrastructure (GIC) by the Spanish Ministry of Science and Technology. Later on (BOE June 16^{th} 2006) the GICs were renamed as "Singular Scientific and Technological Infrastructure" (ICTS). This title acknowledges the important material and human resources of the Centre that are open to offer scientific and technological services and assistance. Thanks to these resources, we are able to develop state of the art in technology and to establish scientific links with other top research Centres, both inside Spain and overseas, in the fields of Micro and Nanotechnology. ISOM is an ICTS in the new map of such facilities elaborated in 2014, working in the network "Spanish Network of Clean Rooms for Micro and Nano Fabrication" also called "MICRONANOFABS" together with the Microelectronics Center (CNM-CSIC) in Barcelona and the Nanophotonics Technology Center (NTC-UPVLC) in Valencia.

The CT-ISOM has a Clean Room and different Laboratories for devices and materials characterization. In these facilities researchers, technicians and administrative personnel work together to sustain our research lines and to provide external services.

The facilities at the CT-ISOM allow the fabrication of different materials, technological processing and the implementation of different devices and integrated electric, optic, optoelectronic, magnetic and nanomaterial structures. Indeed CT-ISOM has the capacity to develop and fabricate LED and laser diodes for instrumentation, environment and optic communications; high power and high temperature microwave transistors; infrared detectors for military and non-military applications; ultraviolet detectors to monitor the UV radiation from the sun and for military applications; visible light detectors for biophotonic applications, magnetic sensors for all sort of applications and also SAW RF filters for sensors and mobile phones and new devices based on graphene. The range of possibilities of the CT-ISOM covers not only the micrometric scale, but also the nanometric frontier (< 300 nm) thanks to the recientedly acquired 50KeV e-beam lithography system. This tool is performing up to its best standards, reaching a line resolution of about 10 nm.

The CT-ISOM has developed processing and fabrication protocols that provide a control of incidences and the final quality of the structure. Each processing order is filed by a "processing form" where all the individual processes and their incidences are recorded. This gives a feedback for future processing so it can be improved or reproduced. The information from these forms is later incorporated to the Specific Protocols of the CT-ISOM.

3.2 Services offered by the CT-ISOM

The CT-ISOM offers external services within the research lines (Chapter VI) and capabilities of the Institute (Chapter V), from a simple characterization to the complete device fabrication (sensors, actuators, transistors, integrated structures, filters, emitters, etc). CT-ISOM has the capability to fabricate and optimize a designed structure thanks to its technology line, design and fabrication of masks, deposition of many types of materials and characterization of the final product/device. These external services are offered to the industry and to the scientific community, national and international. Also we offer a professional training in a specific technological area or equipment practice.

Researchers from Universities, Institutes and Companies interested on using the facilities of the CT-ISOM have now the possibility of doing it under the unified call that will be soon opened by the Network. Find details in our website:

http://www.isom.upm.es

- **CT- ISOM: Singular Scientific and Technological Infrastructure.**
- **Services offered by the CT-ISOM.**

This initiative has the following objective:***"to promote the access of new research groups or individual investigators to ICTS, for the acquisition of new knowledge, their formation on the technology available at the Installation or for the completion of their research work"***

The selection of works that could benefit from the terms of this service is first done by an internal committee from the CT-ISOM, coordinated with the MICRONANOFABS network members. In this evaluation, the viability of the research requested is determined and a number of proposals selected in a competitive frame. Further, an External Committee, formed by prestigious national researchers, chooses and ranks among the proposals selected.

Today, the equipment needed for micro and nanotechnology is very expensive and requires a (also expensive) constant maintenance. Therefore a national policy from MINECO will be launched to improve and maintain the equipments and to allow **all** researchers to access the equipments available at the different ICTS, so they can complete their research.

3.3 Some examples of works done at CT-ISOM

Since its beginning (in year 2000), CT-ISOM has given support and provided services to external users, but from year 2005 the Spanish MICINN (former *Ministerio de Educación y Ciencia*) started a new program to promote and support the use of the ICTS by external users from the academic community. Hence, since 2006 most of the work developed for external users has been funded by the SpanisMICINN. During the last 4 years, without financial budget from MINECO, the CT-ISOM has been keeping working as an ICTS in order to help others research groups in their projects. Since the year 2006, CT-ISOM has performed more than 110 services to external users from the academic community or industry. Some of them represent one week work, but this period of time can be extended up to two weeks for PhD students. There has been a wide plethora of services with different degree of difficulty: from basic standard processing such as microsoldering or reactive ion etching with well known parameters, to more complex and challenging works, mainly related to nanotechnology such as fabrication of nanowires devices.

Here, we mention a couple of examples of work developed at CT-ISOM:

1.- Development of Hall-bars to measure transport properties in graphene.

The goal of this service was to design and build specific Hall-bars to investigate the quantum Hall effect in graphene. Up to this request, ISOM did not have any previous experience on this material; therefore, the difficulty of such work has been twofold: on one hand to determine the proper parameters to be used in all the processing steps; on the other hand, the variety of different processing steps themselves to obtain a final device ready to be used to characterize transport properties in graphene.

The steps to be followed in order to carry out such Hall-bars consist of a preliminary study of dimensions and position of the graphene flakes to be able to contact them. Afterwards the Hall-bar had to be defined on graphene by means of oxygen plasma. Finally, the Hall-bar was contacted to an appropriate holder (non-magnetic) (figures 3.3.1 to 3.3.4).

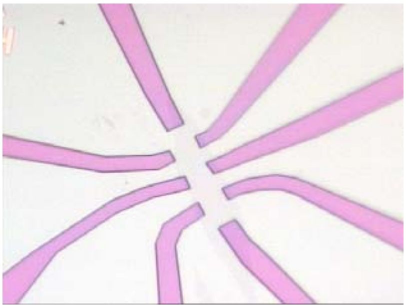


Figure 3.3.1*: Optical image of a lithography on PMMA of contact pads aligned with graphene flake. Ready to evaporate Ti/Au metals.*

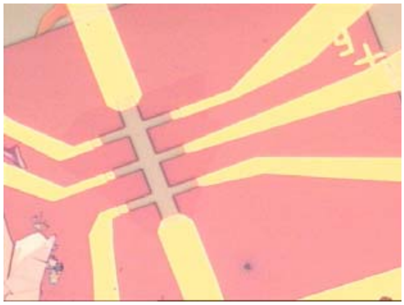


Figure 3.3.2*: Optical image of a lithography on PMMA of MESA, ready for oxygen plasma etching.*

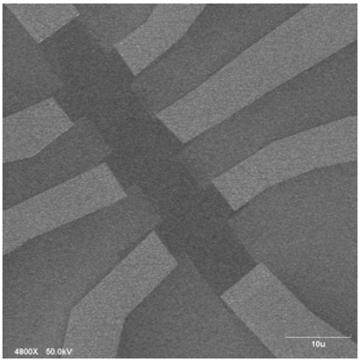


Figure 3.3.3*: SEM image of a Hall bar on graphene, ready to be soldered.*

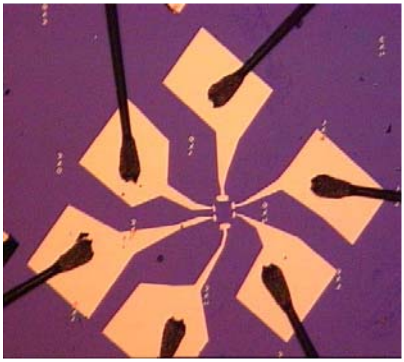


Figure 3.3.4*: Optical image of a complete Hall bar after once soldered to the holder.*

References

[1] E. Diez, V. Bellani, M. Hilke, D. López-Romero, D.K. Maude, D. Shahar, D.L. Sivco, A.Y. Cho, "Saturation Regime in the Quantum Hall Effect". *17th International Conference on Electronic Properties of Two-Dimensional Systems (EP2DS-17) and of the 13th International Conference on Modulated Semiconductor structures (MSS-13)*. Genova, Italy (2007).

[2] M. Amado, E. Diez, V. Bellani, D. López-Romero, P. Orellana, F. Domínguez-Adame, L. Sorba y G. Biasiol, "Control of electron transport in quantum wires and quantum rings with side-coupled nano-gates", *22nd General Conference of the Condensed Matter Division of the European Physical Society*. Roma, Italy (2008).

[3] M. Amado, E. Díez, D. López-Romero, F. Rossella, J.M. Caridad, F. Dionigi, V. Bellani, and D.K. Maude, "Plateau-insulator transition in graphene", *submitted to New Journal of Physics*, 2010.

2.- Gold nanoantennas:

The work proposal was based on the fabrication of periodical gold structures. Such structures were proposed as dimer and trimer-type, all of them with critical dimensions close to 10 nm (figures 3.3.5-3.3.6). Therefore the challenge here was to reach the desirable dimensions in the very limit of our nanolithography system.

The final objective of these processes is the characterization of the electromagnetic field near the nanostructures by means of SNOM (Scanning Near-field Optical Microscopy), and study the resonance near the wavelength of the surface plasmons on nanostructures. The results will be compared with former theoretical calculations developed by the user.

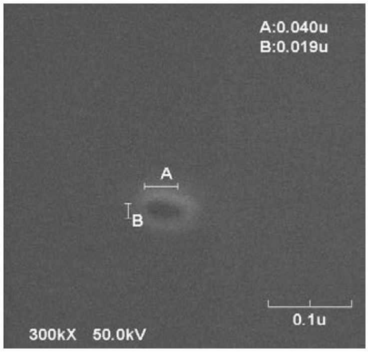


Figure 3.3.5*: SEM image showing typical dimensions of the monomer structure for the nanoantennas pattern.*

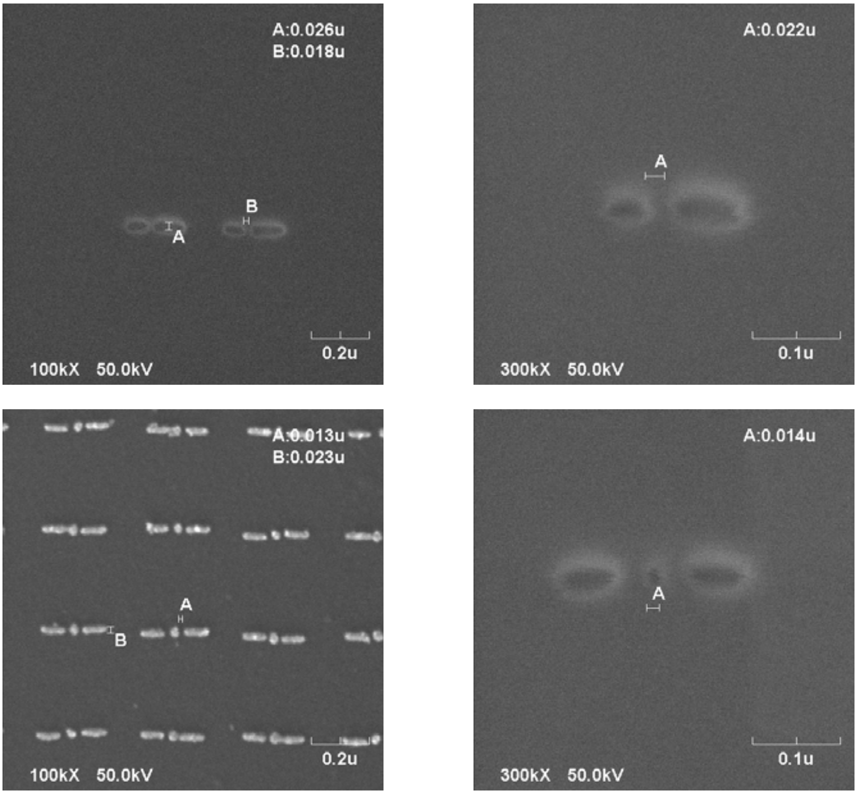


Figure 3.3.6*: SEM images showing a dimer structure (upper) and a trimer structure (lower)*

After having successfully obtained the nanostructures, some surface characterization was performed by AFM (Atomic Force Microscopy) as shown in figure 3.3.7.

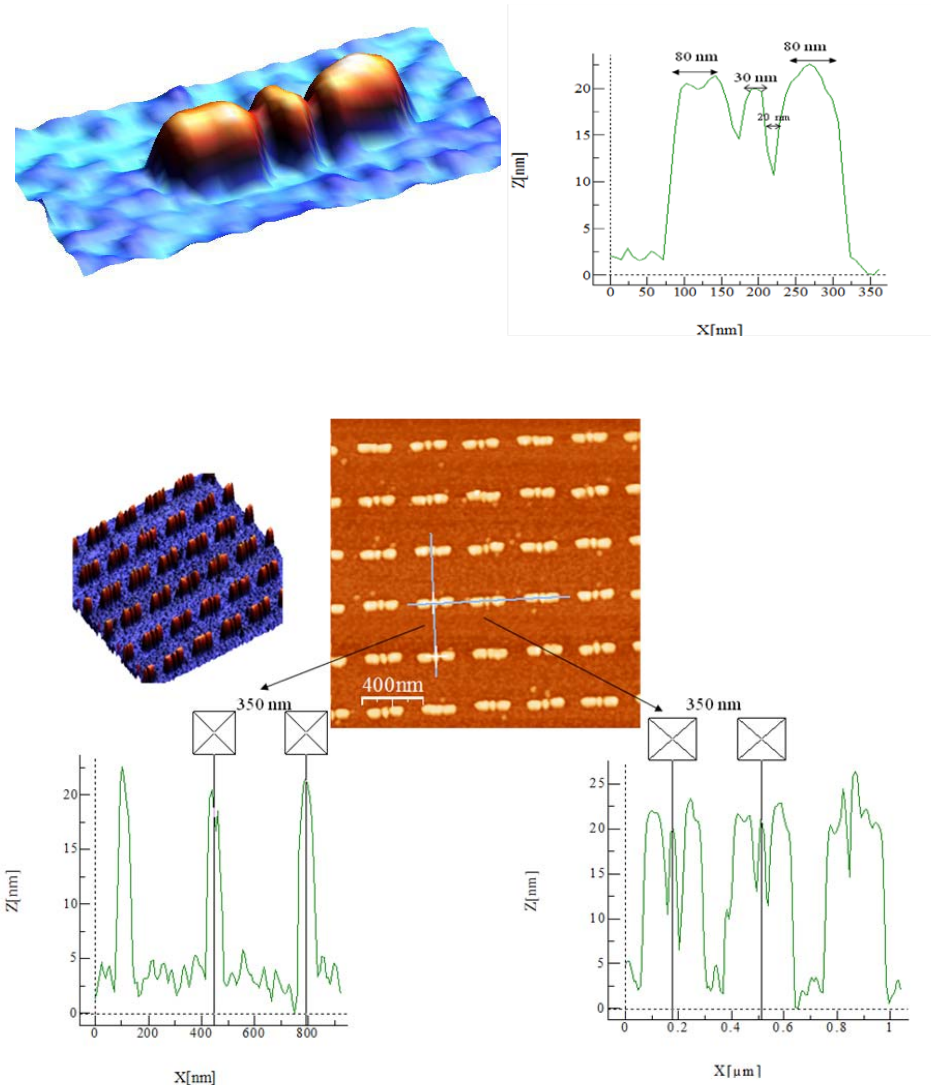


Figure 3.3.7: *AFM characterization of the gold trimer structure*

References

[1] R. Rodríguez-Oliveros, J.A. Sánchez-Gil, , M.U. González, A. Vitrey, D. López-Romero, M.M. Sanz and C. Domingo, *to be submitted to Optics Express.*

3.- Development of Silicon Nanowire Biosensors.

In this service, the goal was to design and build Silicon Nanowires with thickness of 10 to 50 nm in order to be used as Biosensors at the Nanoscale (fig. 3.3.8). In this request, the starting material was commercial SOI (Silicon On Insulator), so the CT-ISOM had to determine the proper parameters to be used in all the processing steps. The final devices have been electrically characterized in order to study its properties as nano-transistor.

The nanowires can be done in two different approaches. The first one is by ebeam lithography, and the other option is to make a hard mask by local oxidation by Atomic Force Microscopy (AFM). Afterwards the nanowire had to be defined on the top silicon by means of a Reactive Ion Etching. Once the nanowire is defined, the next thing is to make a second ebeam lithography step to be able to contact it. Finally, the silicon nanowire was contacted by optical lithography with larger pads.

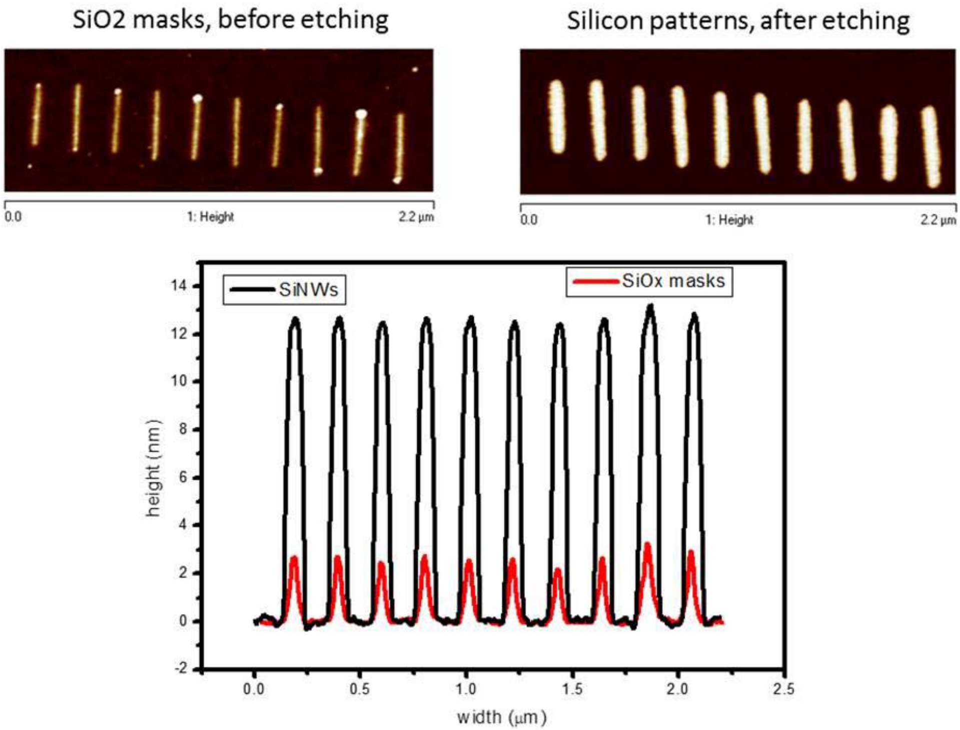


Figure 3.3.8: On the left:AFM image of diferent nanowire masks fabricated with the local oxidation method.On the right: Silicon nanowires obtained after the RIE etching process. Below: Section analysis of the local oxidation mask and the silicon nanowire.

4 TECHNOLOGICAL AND CHARACTERIZATION FACILITIES

Compact 21S RIBER MBE system dedicated to the growth of III-Nitrides materials (GaN, AlN, InN and their alloys). The MBE system has 7 source ports, including a central flange for the installation of the radio-frequency plasma source to activate the nitrogen. Introduction of samples is implemented by the use of a loadlock chamber. The system is also provided with standard in-situ real-time characterization techniques such as RHEED (reflection high energy electron diffraction) and RGA (residual gas analyzer).

4.1 Materials Growth and Processing Systems

- Molecular Beam Epitaxy (MBE) (4 systems)
- Magnetron Sputtering (4 systems)
- Chemical Vapour Deposition systems (CVD and PECVD) for Graphene and dielectrics
- UV Photolithography MJB3 aligner (resolution >1 µm)
- UV Photolithography MJB4 aligner (resolution 500 nm)
- High resolution e-beam nanolithography system (Crestec, line resolution 10 nm)
- Colloidal nanolithography system
- Metal Deposition (Joule and e-beam evaporation) (5 systems)
- Ar- Ion Milling system
- Standard and Rapid Thermal Annealing (RTA) (5 systems)
- Reactive Ion Etching (RIE)
- Inductive Couple Plasma system for dry etching (ICP)
- High precision Blade (3 systems) and Diamond Scribers
- Ultrasound and Thermocompression Microsoldering (2 systems)

4.2 Characterization Systems

A) Surface and Structural properties

- High Resolution X-Ray Diffractometer (HR-XRD) (Panalytical X'Pert Pro)
- Scanning Electron Microscope (SEM) with EDAX/EBIC and FESEM with CL (2 systems)
- Atomic Force Microscope (AFM) with I-V stage
- Thickness Profiler (DekTak)
- Optical Profiler by interferometry

B) Electric and Magnetic properties

- Electronic Systems for Characterization and Measurement (curve tracer, curve analyzer, sampling oscilloscopes, nanovolt generators, lock-in amplifiers, etc.)
- Cryogenic Hall Effect system
- Cryogenic Giant Magnetoresistance system
- Microprobe station and systems for RF (up to 20 GHz) network analysis
- Carrier Traps and Defect Analysis Techniques (DLTS, PCFRS, AS)
- Electrochemical C-V Profiler
- Magnetic Characterization (Vibrating Sample Magnetometer: VSM)
- Magnetic transport measurements, including spin transfer and velocity of domain walls with a 2,5 GHz oscilloscope

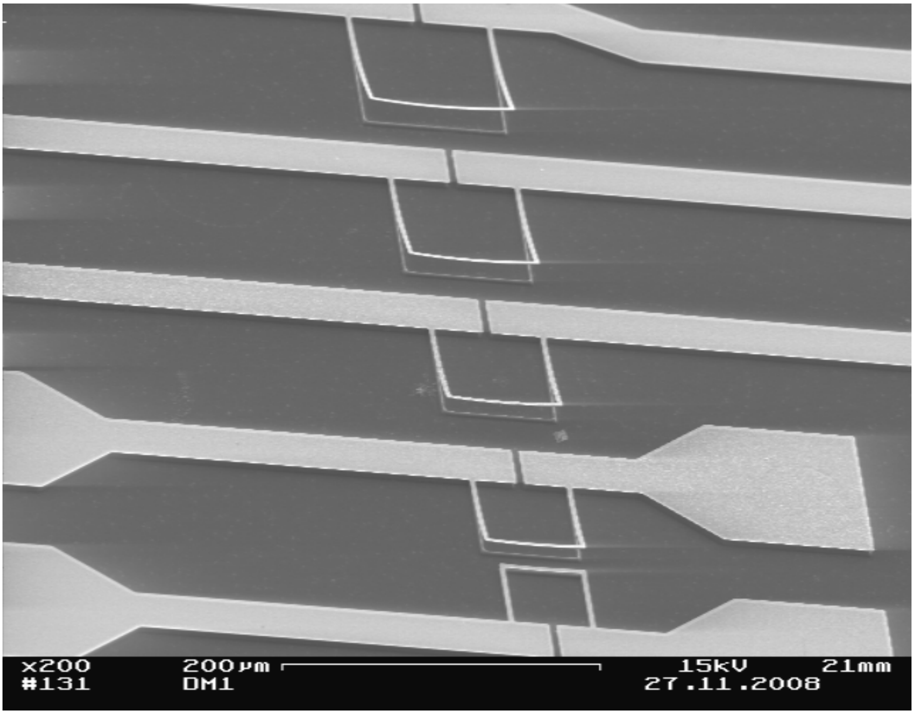
C) Optical properties

- UV to IR photoluminescence (PL) (4 systems)
- Cathodoluminescence system (CL) linked to a FESEM microscope with spatial resolution (UV to IR)
- VIS and IR Fourier Transform Absorption Spectrometer (FTIRS) (Nicolet 760)
- Electroluminescence system (LEDs)
- High Resolution Nomarski Optical Microscopy
- Cryogenic systems (5 systems)

D) Device characterization

- Probe Stations (low Capacitance) for VLSI and discrete devices (2 systems)
- Electrical and Optical Characterization at high T (up to 400ºC)
- Electrical Characterization systems for Transistors and Devices up to 1 GHz (C-V, I-V, C-f, 1/f noise, T, etc.)
- Photonic Devices Characterization systems
- Image Capture and Analysis system
- Optical Characterization of Lasers and LEDs
- Optical Characterization of Detectors

5 RESEARCH LINES



SEM micrograph of an array of U-frame resonators, used to determine the dynamic acoustic velocity, with W = L. The observed out-of-plane deflection is due to the large tensile residual stress in the metal layer covering the structure.

5.1 Optical and Electronic Devices and Systems

A) *UV photo-detection systems* ***(Prof. E. Muñoz, Dr. A. Hierro)***

- UV radiation monitoring based on wide bandgap semiconductors (GaN and ZnMgCdO alloys): solar sensitive/solar blind applications, light polarization detection.
- Applications of UV detectors in astrophysics, fire detection systems, combustion control and water contaminant detection.
- VIS and UV photodetectors for integrated biosensors and fluorescence systems.

B) *Infrared photo-detection systems* ***(Dr. A. de Guzmán, Dr. A. Hierro, Prof. E. Calleja, Dr. M.A. Sánchez)***

- High sensitivity and multispectral response detectors. AlGaAs/InGaAs quantum well and dot (QWIP's, QDIP's) technology.
- Focal plane arrays for night vision systems.
- Multispectral integration. Associated electronics.
- Intersubband photodetection with ZnCdMgO nanostructures.
- InN QWs for photodetection at 1.5 µm.

C) *Components for optical communications, quantum computing, and lighting* ***(Dr. A. Hierro, Dr. J.M. Ulloa, Dr. A. de Guzmán, Prof. E. Calleja, Dr. M.A. Sánchez)***

- LEDs/LDs/Photodetectors for optical communications at 1.3 and 1.55 µm with QWs and QDs based on GaAs(Sb)(N).
- UV LED emitters incorporating QWs and QDs based on III-Nitrides.
- Phosphor-free white light nanoLED arrays based on III-Nitrides.
- Ordered Dot-in-a-Wire arrays for Single Photon Emision based on III-Nitrides.

D) *Nanophotonic Biosensors* ***(Dr. C.A. Barrios)***

- Optical biosensors integrated in a chip (Lab-on-a-chip).
- Nanostructured materials for optical biosensing.
- Wearable optical (bio)sensors.

E) *Devices for energy conversion and photovoltaics* ***(Prof. E. Calleja, Prof. E. Muñoz, Prof. F. Calle, Dr. M.A. Sánchez, Dr. J.M. Ulloa, Dr. A. Hierro)***

- High efficiency InGaN heterojunction (nano) Solar Cells grown by MBE.
- High Performance Organic-Nanorod Hybrid Photovoltaic Devices.
- Nitride-based HEMTs and switches for efficient energy power converters.
- MEMS and NEMS for energy harvesting based in nitrides and oxides.
- GaAs(Sb)(N)-based nanostructures and thick layers for tandem Solar Cells.

F) *Electronic devices and microsystems for communications* ***(Prof. E. Muñoz, Prof. F. Calle)***

- AlGaN/GaN HEMTs for µwave applications (X- and L-Band). Manufacturing technology. Transport properties, piezoelectric effects, reliability.
- Surface Acoustic Wave (SAW) RF devices.
- MEMS y NEMS: nanoresonators, RF-switches.

- High temperature device performance and applications.

G) *Graphene Devices* ***(Dr. J.Martínez, Dr. J. Pedrós, Dr. M. Muñoz, Prof. F. Calle)***

- PE-CVD of 2D and 3D structures and automatic transfer.
- Electrical characterization of graphene devices.
- Graphene field-effect transistors and sensors.
- Spintronics in graphene and 2D materials.
- Flexible electronics.
- Supercapacitors.
- Plasmonics.

5.2 Magnetic Materials and Systems

A) *Magnetic sensors and Devices* ***(Prof. C. Aroca, Prof. P. Sánchez)***

- Magnetometric sensors for low magnetic field measurements: fluxgates, piezoelectric magnetostrictive, magnetoresistive and magnetooptic sensors.
- Multisensors:
  - Vehicle detection applications
  - Ground airplane control and guiding
  - Applications to monitoring large battery complexes
- Planar devices. Applications to planar inductors for commuting sources and antennas.
- Low frequency intelligent cards with magnetic sensors.

B) *Spintronics* ***(Dr. J.L. Prieto, Dr. M. Muñoz)***

- Metallic magnetic multilayers. Spin valves. CPP measurements.
- Dynamics of magnetic domain walls around defects in magnetic nanowires.
- Spin transfer torque on magnetic domain walls and magnetic nanostructures.

C) *Magnetic Nanoparticles* ***(Dr. M. Maicas, Dr. M. Sanz)***

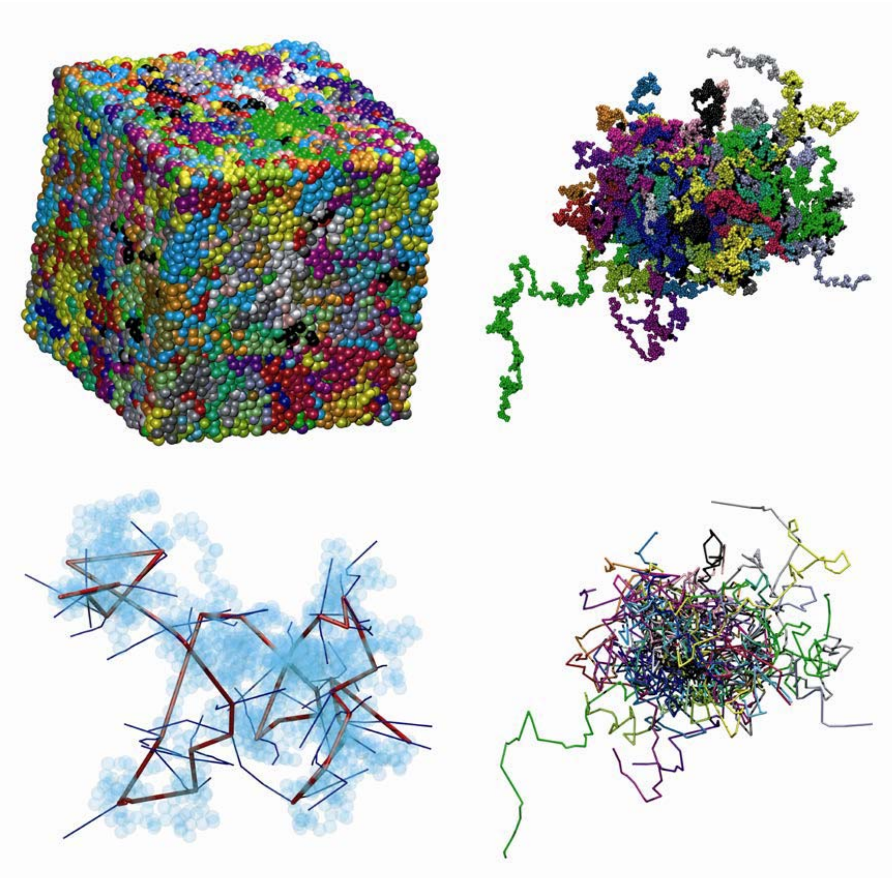
- Magnetic nanoparticles synthesized by sputtering.
- Magnetic nanodots.
- Nanoparticles for biomedical applications.
- Magnetic simulation and modelling using Finite Element Methods.

5.3 Non-metallic materials simulation

(Prof. M. Laso, Dr. Nikolaos Karayiannis)

- Non-metallic materials and complex fluid simulation.
- Molecular dynamics methodology and advanced Monte Carlo techniques.
- Adsorption and nanostructured materials.
- "Single-molecule" sensors for biomolecules (proteins, toxins).
- Jammed structures and glassy materials.

6 RESEARCH REPORTS



Clockwise from top left: Representative configuration of 54-chain, hard-sphere system of molecular length 1000 in the vicinity of the MRJ state, with coordinates of sphere centers (a) wrapped, subject to three-dimensional periodic boundary conditions and (b) fully unwrapped in space. (d) The underlying primitive path network, after the application of the Z1 topological algorithm, with entanglement coordinates unwrapped in space. (c) An arbitrary selected single chain of high knotting complexity (10.153) with constituent sites shown as transparent spheres. Also shown is the corresponding primitive path, and segments of other primitive paths with which it is entangled.

6.1 Room temperature operation of laterally biased Quantum Well Infrared Photodetectors [1]

Álvaro Guzmán, Raquel Gargallo-Caballero, Rocío San-Román and María-José Milla

Since 1996 the Institute has an active research line focused on the development of Quantum Well Infrared Photodetectors (QWIP) based on GaAs. These devices have been evaluated as good candidates to develop high yield infrared (IR) cameras. The GaAs / AlGaAs material system allows the QW potential profile to be tailored over a wide enough range to enable light detection at wavelengths longer than 3.5 µm. The easy growth and processing of these materials allow obtaining large uniform focal plane arrays of QWIP's tuned to detect light at wavelengths from 3.5 up to and beyond 25 µm. Moreover, hybrid devices combining a focal plane array with a Read Out Integrated Circuit made on Si, bonded together by flip-chip techniques, have been developed, being already commercially available [1].

However, IR cameras based on QWIPs still show important drawbacks. For instance: the need of cooling down to cryogenic regimes to reduce the dark current, or the strong reduction in the light absorption in normal incidence conditions due to the selection rules of intraband transitions. The latter normally leads to the need of etching diffraction gratings on the active surface of the pixels to scatter the light [2]. As a consequence of all these drawbacks, the QWIP- based cameras are generally mounted inside expensive and heavy cryostats which make the whole system very difficult to be carried by an operator, being its use restricted to surveillance or security systems.

Therefore, one of the main objectives of the Institute is to develop QW- IR detectors which can operate at room temperature (RT) under normal incidence conditions. Different approaches have been exploited to reach higher operation temperatures, including: i) the growth of asymmetric confining barriers at both sides of the QW to enhance the photovoltaic response of the detectors [3]; ii) or the use of quantum dots (QD) in the active region. The former approach allows operating the device at 0V bias, with a very low dark current. In the latter, the 0 dimension nature of the QD bound energy states is expected to inhibit phonon scattering, thus increasing the relaxation times, and consequently, more efficient detection is predicted. With these devices, we have reached operating temperatures of 180 K. [4]

However, more challenging structures are needed to reach the desired RT detection. In 2007 P.M. Alsing, D.A. Cardimona et al, proposed a novel QW- IR detector structure with a lateral biasing scheme which can, in theory, work at higher temperatures [5]. They consider a double QW structure (fig. 6.1.1.a) consisting on a n-type doped QW tunnel-coupled with another n-type doped QW. Both wells are laterally contacted by means of two ohmic junctions (collector contacts) at the sides of the device. Furthermore, two pinch-off Schottky gates are deposited to reduce the direct conduction between the lateral contacts through the QW. This conduction is reduced by applying an electric field to the pinch-off gate in a fashion similar to a field effect transistor for each QW. When the electrons in one of the QWs are promoted from the ground state to the excited state (fig. 6.1.1.b) they tunnel out to the other QW. The electrons are then swept to the collector region by means of the lateral bias. It is also possible to apply a vertical bias (parallel to the growth direction) using the bias gate. In this case, there is a shift of the relative energy between the levels in the first QW which allows the tuning of the peak wavelength response of the detector. As a general advantage, since the dark current of the device can be reduced by means of the control gate, it is expected to obtain IR detection at RT.

[1] *Contact person: Álvaro de Guzmán Fernández* guzman@die.upm.es

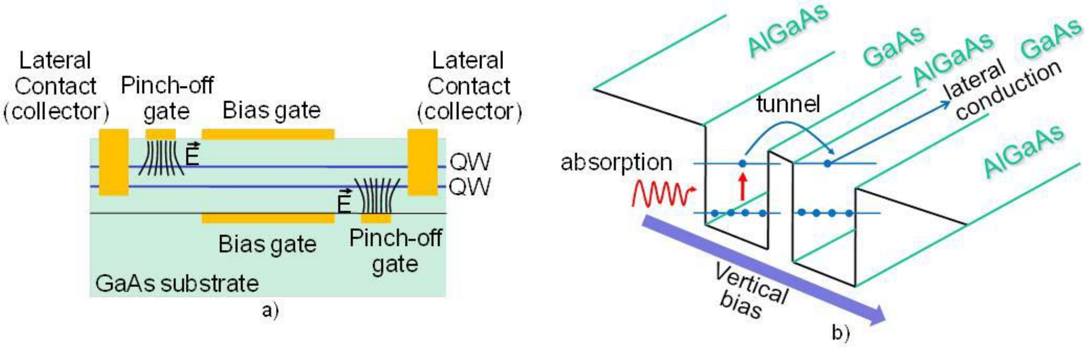


Figure 6.1.1. *Cross-sectional structure (a) and band profile (b) of a laterally biased photodetector. The lateral contacts are used to collect the photocurrent. The pinch-off gates allow creating an electric field to reduce the dark current. The bias gates can be employed to bend the bands, tuning the absorption wavelength of the device. The band profile summarizes the work principles of this detector.*

In 2009 an Award from the Air Force Research Laboratory (USA) was granted to the ISOM to work in collaboration with Dr. D. Cardimona. This project, still in progress, aims to the fabrication of lateral QWIPs using MBE regrowth of the active region on top of ion implanted surfaces.

During the last 4 years a strong effort has been devoted to the optimization of the growth conditions, the improvement of the technology, and the search for the most suitable detector structures. As a result, RT intraband absorption peaks have been observed for the first time.

Detectors development and results

The processing steps of the device are detailed in figure 2. The AlGaAs/GaAs QWs were grown by Molecular Beam Epitaxy (MBE) using a RIBER 32 system. One of the major difficulties of this structure is the location of the bias and pinch-off gates at the bottom side of the device. They have to be deposited previous to the growth of the epilayer. In our case, those gates were fabricated by selective ion implantation on a 2” GaAs undoped wafer.

In a first step (fig. 6.1.2.a) several alignment marks are etched by Reactive Ion Etching (RIE) in order to further align the following processing steps. Then, a series of windows were opened in a photoresist film (fig. 6.1.2.b) and the full wafer was exposed to the Si^+ ion beam using a dose of $4 \cdot 10^{13}$ cm^{-2} and an implantation energy of 180 KeV (fig. 6.1.2.c). The peak of the vertical implantation profile ($2 \cdot 10^{18}$ cm^{-3}) was designed to be 500 nm deep from the surface.

After the implantation, the sample was immersed in a solution of H_2SO_4:H_2O_2:H_2O 1:8:80 during 2 minutes to clean and etch the surface and then rinsed with DI water. It was further left in flowing DI water during 15 minutes to deposit a protective oxide layer prior to loading it into the MBE system.

The epilayer was grown at 600ºC with a V/III beam equivalent pressure ratio of 25 (fig. 6.1.2.d). The growth was monitored by in situ Reflection High Energy Electron Diffraction. After the oxide desorption at 580ºC we raised the temperature up to the transition between the (2x4)-α and the (2x4)-β surface reconstructions observed at 600ºC. The structure grown consisted of two 5.5 nm wide GaAs QW doped with Si to $2 \cdot 10^{18}$ cm^{-3} separated by 3 nm $Al_{0.25}Ga_{0.75}As$ barriers. This structure is sandwiched between two $Al_{0.25}Ga_{0.75}As$ barriers 30nm wide.

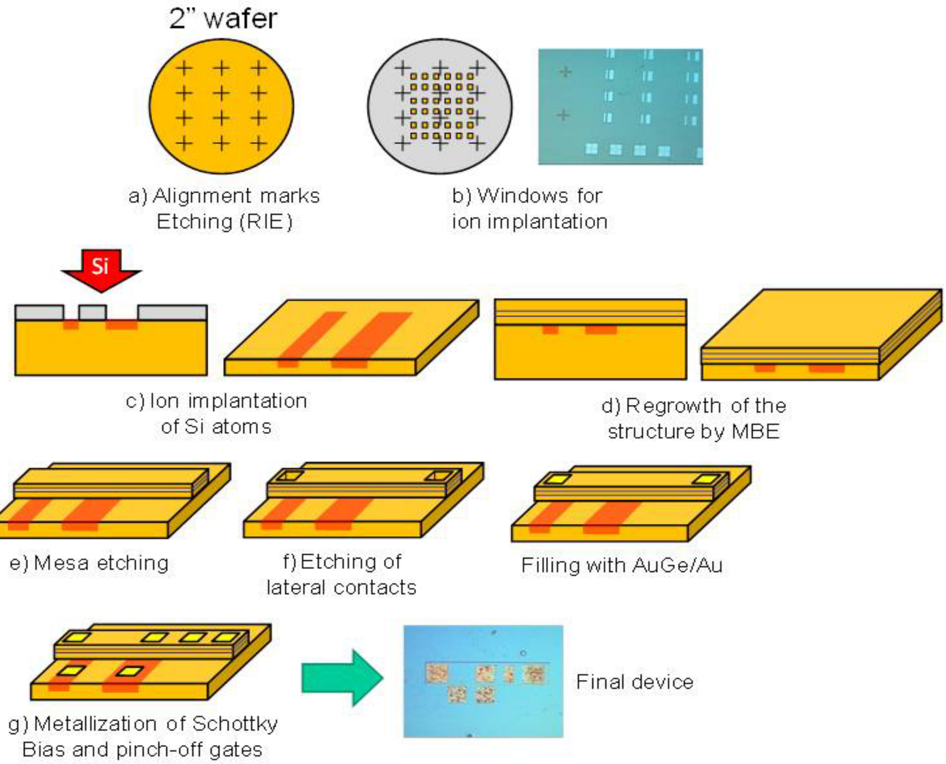


***Figure 6.1.2**. Processing steps in the fabrication of the laterally biased device shown in figure 1.*

The quality of the regrown material was evaluated by four different techniques: Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray diffractometry (XRD), and Atomic Force Microscopy (AFM). Figure 6.1.3 shows the results of the characterization, where it can be seen how the structural quality of the epilayer is comparable to the quality of the native substrate, both in surface roughness and crystal quality.

In the next step (fig. 6.1.2.e) a mesa etching was performed to isolate the device. Two 100x100 μm square wells were etched by RIE and filled with AuGe / Au (fig. 6.1.2.f) to fabricate the lateral ohmic contacts. Finally, the metallization of the Schottky bias and pinch-off gates were performed using standard Joule evaporation of Au and further lift-off (fig. 6.1.2.g). The final device was measured in an optical bench consisting of a Globar (glow bar) lamp, an IR monochromator, and ZnSe lenses. The photosignal was collected by a lock-in amplifier.

To assess the adequacy and performance of the processing procedure, the I-V characteristics of the device was measured using a Hewlett-Packard 4145 parameter analyzer. Since the lateral contacts are 100x100 μm square shaped, the thickness of the QWs is 5.5 nm and the length between contacts is 1 mm, we can estimate the resistance of the QWs taking into account the material parameters of the GaAs. This estimation yields a result of R=20 KΩ, which is in good agreement with the I-V characteristic, where a clear ohmic behaviour with a resistance of 14 KΩ can be observed.

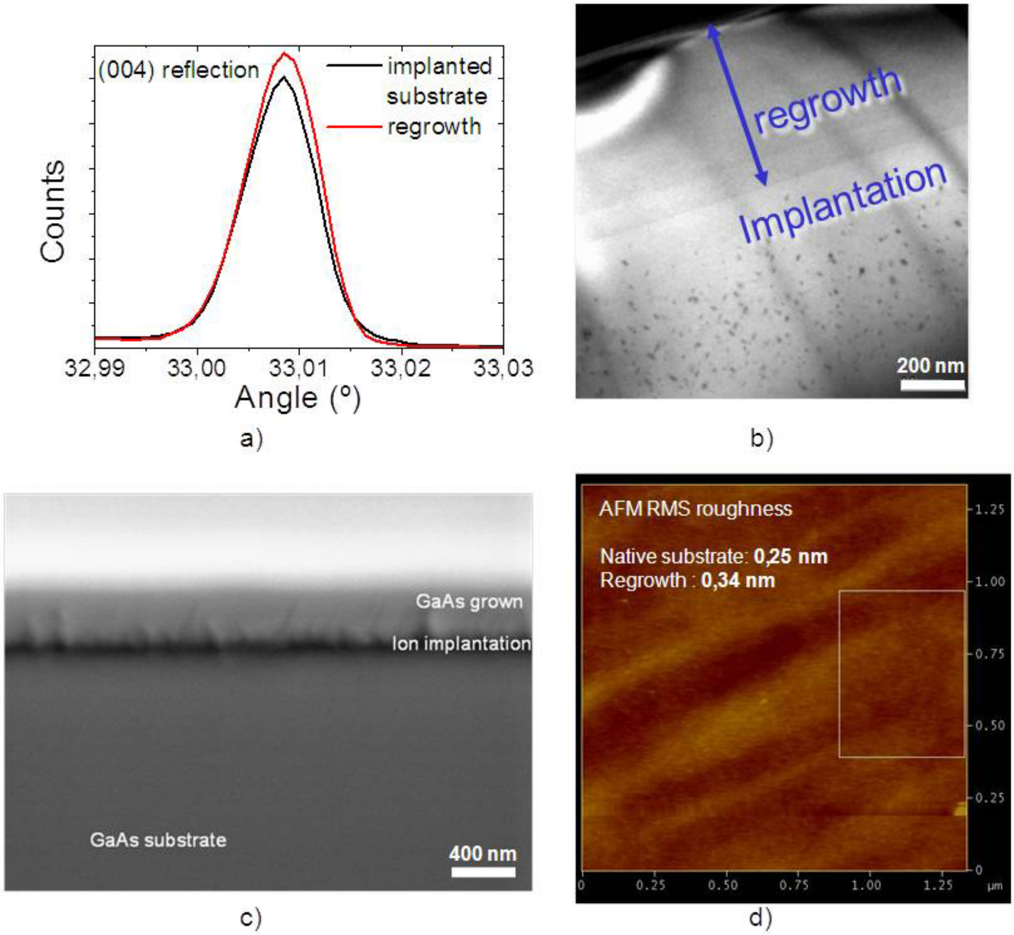


Figure 6.1.3. *Assessment of the quality of the regrown layer: a) XRD curves of the native GaAs substrate and the layer regrown; b) Cross-sectional TEM showing good crystal quality (Courtesy of Dr. E. Luna, Paul Drude Institut für Festkörperelektronik, Berlin, Germany); c) SEM image showing the implanted and regrown layers; and d) AFM image showing good surface roughness compared to that of the substrate.*

The measured the I-V curve of the pinch-off gate with respect to one of the ohmic contacts, which is chosen as the ground, shows a good rectifying behaviour, with 4 orders of magnitude of difference between the measured current in direct and reverse bias.

Finally the photocurrent of the laterally biased QWIP was measured under normal incidence at RT at a bias of 3,5V between lateral contacts and 0 V in the Schottky gates. Figure 6.1.4.a shows a very clear peak centered in 8.5 µm corresponding to the transition between the QW ground state and the first excited state.

The transmission coefficient through the QW structure was calculated using a transfer matrix method which considers the electric field present in the structure, as well as the different band. This method predicts a difference of 146 meV between the resonances corresponding to the ground state and the first confined state in a 5.5 nm QW surrounded by $Al_{0.25}Ga_{0.75}As$ barriers and kept under a bias voltage of 3V. This value is in good agreement with the peak measured at 8.5 µm (equivalent to a difference of 145 meV). The results of this simulation are also included in figure 6.1.4.b. This is, to our knowledge, the first observation of intraband photocurrent at room temperature [6].

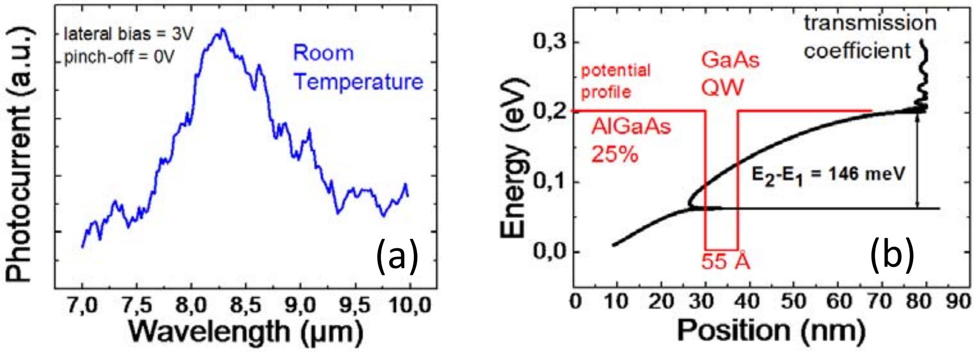


***Figure 6.1.4**. a) Room temperature photoresponse of a laterally biased QWIP measured with 3V of lateral bias and 0V at the Schottky pinch-off gates. b) Simulation by transfer matrix. The results agree with the experimental peak.*

Currently the main efforts along this research line are projected to enhance the quality of the devices. New ideas are being explored and novel structures and concepts are being considered. Thanks to the support of the AFRL, an Ar ion gun has been installed in a vacuum chamber connected to the MBE reactor. This allows the substrate surface to be patterned before the regrowth without exposing the samples to the atmosphere. With this equipment a new developed generation of devices have already shown a higher material quality compared to those regrown after chemical etchings. These devices are expected to demonstrate much better performance and superior figures of merit in a close future.

References

[1] http://www.irnova.se, last access: December 2013.

[2] T. Fujii, P. Masalkar, H. Nishino, et al. *Infrared Physics & Technology* **42**, 199 (2001).

[3] E.Luna, J.L. Sánchez-Rojas, A.Guzmán, J.M.G. Tijero and E.Muñoz. *IEEE Photonics Technology Letters* **15**, 105 (2003).

[4] E. Luna, A. Guzmán, J.L. Sánchez-Rojas, J.M.G. Tijero, R.Hey, J. Hernando y E. Muñoz. *Journal of Vacuum Science and Technology B* **21**, 883, (2003).

[5] P.M. Alsing, D.A. Cardimona, D.H. Huang, T. Apostolova, W.R. Glass, C.D. Castillo, *Infrared Physics & Technology* **50,** 89 (2007).

[6] A. Guzmán, Rocío San-Román, and Adrián Hierro, *Journal of Crystal Growth* **323**, 496 (2011).

6.2 Zn(Mg,Cd)O alloys for optoelectronics[2]

Adrián Hierro

The use of ZnCdO and ZnMgO alloys allows covering a wide spectral region, from 2.2 eV in CdO, through 3.37 eV in ZnO, all the way to 7.8 eV in MgO, in an alloy with a very large exciton binding energy (60 meV in ZnO). This flexibility in bandgap engineering together with the recent availability of large single crystal substrates opens new doors for optoelectronic applications. Among the devices currently being analyzed and developed at ISOM all photoconductors, Schottky and MSM photodiodes covering the UV to VIS region are included, where ZnMgO or ZnCdO are used to tune the detection wavelength both in thin layers or in nanowires. Additionally, quantum wells (QWs) are also used to allow lattice matching over ZnO substrates, enhancing the crystal quality and carrier confinement. Since one important goal is to develop bipolar photonic devices, such as light emitting diodes (LED) and laser diodes (LD), the identification of the mechanisms limiting p-type doping in these oxides is also being investigated focusing on deep level formation and paying particular attention to crystal polarity and alloy composition..

The work at ISOM is the result of several fruitful ongoing collaborations with the following groups: Univ. Shizuoka in Japan (Profs. J. Temmyo and A. Nakamura, RPE-MOCVD growth), CRHEA-CNRS/Univ. Nice in France (Prof. J.M. Chauveau, MBE growth), and Univ. Valencia (Prof. V. Muñoz Sanjosé, MOCVD+spray pyrolisis growth, and HRTEM/EDX analysis). The main areas covered are:

A. $Zn_{1-x}Cd_xO$ alloys.

UV-VIS ZnCdO nanowires. [1]

$Zn_{1-x}Cd_xO$ nanowires are grown by RPE-MOCVD with room temperature photoluminescence (PL) energies covering the spectral region from 3.3 eV down to 1.9 eV, corresponding to a measured Cd concentration in the nanowire from 0% to 54%. Analysis of the microstructure in individual nanowires confirms the presence of a single wurtzite phase (fig. 6.2.1) even at the highest Cd contents, with a homogeneous distribution of Cd both in the longitudinal and transverse directions (fig. 6.2.2), and no indication of crystal phase separation or Cd accumulation. These nanowires have radiative efficiencies that compare well to that of the reference ZnO nanowires (fig. 6.2.3). Even though the growth temperature is quite low in these nanowires (300ºC) thermal annealing up to 550ºC may be used in future device processing. Indeed, after a 550ºC annealing, the single wurtzite structure is completely maintained even with 45% Cd, and the only detrimental effect is the PL blue shift that arises from a homogeneous reduction of Cd along and across the nanowire, which is lost through evaporation.

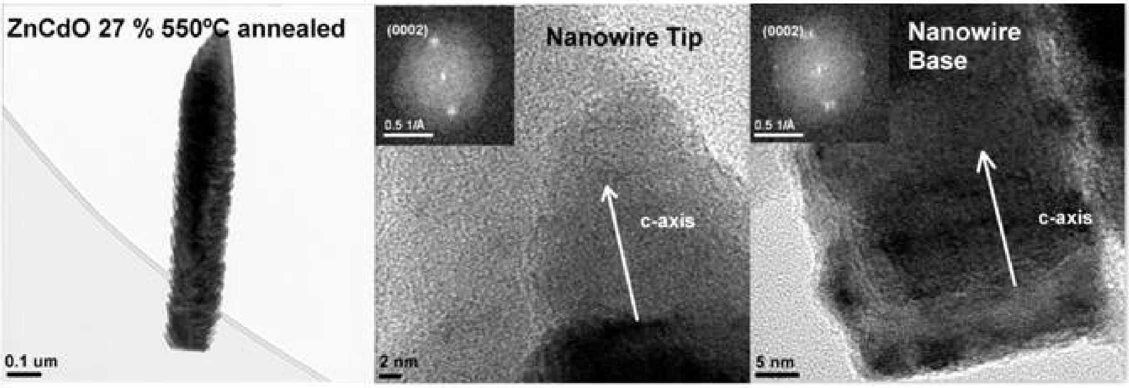


***Figure 6.2.1**. TEM images of a single ZnCdO(2nm)/ZnO(10nm) multiple well nanowire.*

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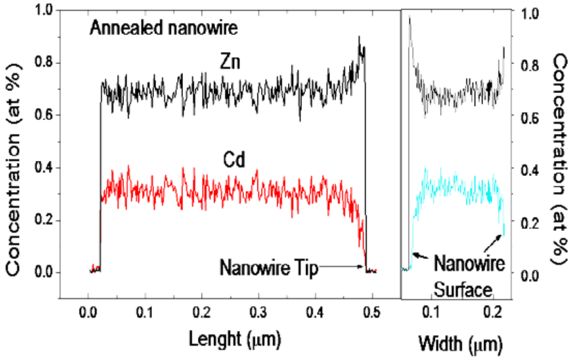

***Figure 6.2.2**. Cd/Zn concentration profiles along and across an individual annealed $Zn_{0.73}Cd_{0.27}O$ nanowire measured by micro-EDX.*

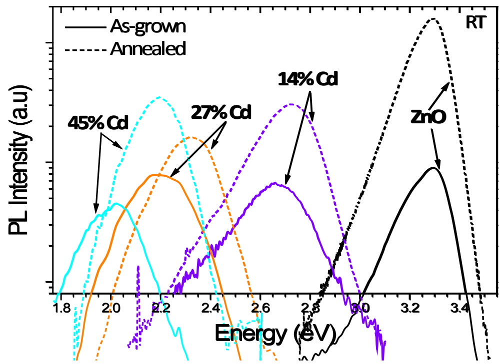

***Figure 6.2.3**. Dependence on Cd content of the RT-PL peak energy, intensity and FWHM, both for the as-grown and annealed $Zn_{1-x}Cd_xO$ nanowires.*

ZnCdO/ZnO heterostructures in a nanowire. [2]

$Zn_{1-x}Cd_xO/ZnO$ heterostructures grown by RPE-MOCVD have been demonstrated within a single nanowire, with up to 10 periods (fig. 6.2.4). The well width was varied from 10 to 1.7 nm, allowing the LT-PL emission to cover almost the entire visible range, from 1.97 eV to 3.03 eV. High radiative recombination rates were obtained in the thinner wells, comparable to that from a ZnO reference. HRXRD, HRTEM and micro-EDX line scans proves the existence of multiple well structure within the single nanowire. However, a direct measurement of the Cd content along the nanowire indicates that Cd is strongly diffused to the barrier, decreasing the net Cd concentration in the well.

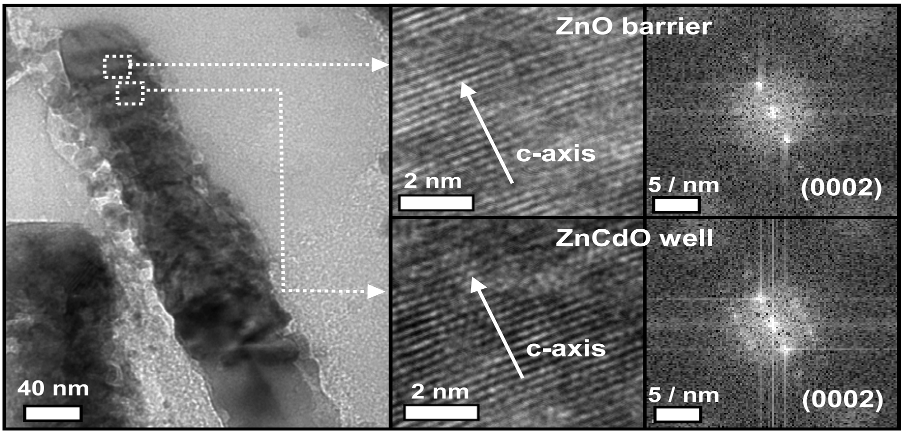

***Figure 6.2.4**. TEM images of one single ZnCdO(2nm)/ZnO(10nm) multiple well nanowire.*

Visible ZnCdO/ZnO multiple quantum well LEDs. [3]

$Zn_{0.8}Cd_{0.2}O/Zn_{0.92}Cd_{0.08}O$ multiple quantum well (MQW) light-emitting diodes (LEDs) on p-type 4H-SiC substrates, using RPE-MOCVD, have been fabricated and characterized (fig. 6.2.5). Band-edge green electroluminescence (EL) at 500 nm has been obtained at room temperature. The ZnCdO MQW LEDs show a rectifying current–voltage behavior with a turn-on voltage of 6.0 V. The integrated EL intensity linearly increases with increasing injection current density up to 1.9 A/cm^2 (fig. 6.2.6). Furthermore, the presence of an EL blue-shift of 20 nm with increasing current and a large EL spectral width in comparison to PL are likely the result of Cd compositional fluctuations.

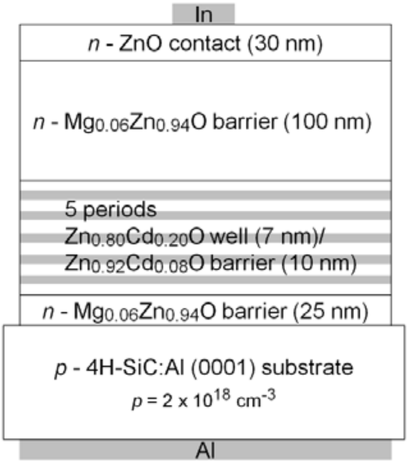

***Figure 6.2.5**. Schematic diagram of the 5-stacked ZnCdO/ZnO MQW LED.*

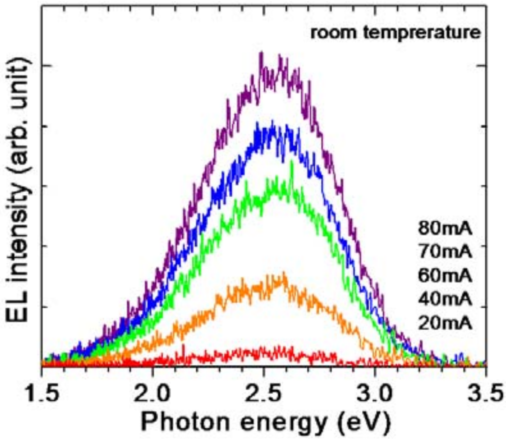

***Figure 6.2.6**. Visible EL spectra of a ZnCdO/ZnO MQW LED driven at various injection current densities up to 1.9 A/cm^2 at room temperature.*

B. $Zn_{1-x}Mg_xO$ alloys.

High Mg content ZnMgO: solar blind UV photodetectors. [4][5]

Deep level defects in n-type unintentionally doped a-plane $Zn_{1-x}Mg_xO$, grown by MBE on r-plane sapphire, have been fully characterized using deep level optical spectroscopy (DLOS) and related methods. This work is a collaboration with Prof. Steve Ringel, from Ohio State Univ. (USA). Four compositions of $Zn_{1-x}Mg_xO$ were examined with x=0.31, 0.44, 0.52, and 0.56 together with a control ZnO sample (Table 6.2.1). DLOS measurements have revealed the presence of five deep levels in each Mg-containing sample, having energy levels of E_c-1.4 , 2.1 , 2.6 eV, and E_v+0.3 and 0.6 eV. For all Mg compositions, the activation energies of the first three states were constant with respect to the conduction band edge, whereas the latter two revealed constant activation energies with respect to the valence band edge. In contrast to the ternary materials, only three levels, at E_c-2.1 eV, E_v+0.3 and 0.6 eV, are observed for the ZnO control sample in this systematically grown series of samples. Substantially higher concentrations of the deep levels at E_v+0.3 and 0.6 eV were observed in ZnO compared to the Mg alloyed samples (Table 6.2.1). Moreover, there is a general invariance of trap concentration of the E_v+0.3 and 0.6 eV levels on Mg content, while at least and order of magnitude dependency of the E_c-1.4 , and 2.6 eV levels in Mg alloyed samples.

Resonant Rutherford backscattering spectrometry combined with ion channeling films (in collaboration with A. Redondo, ITN Portugal) reveal a uniform growth in both composition and atomic order in these, as well as Mg contents higher than 50%. The lattice-site location of Mg, Zn and O elements was determined independently, proving the substitutional behavior of Mg in Zn-sites of the wurtzite lattice. X-Ray diffraction pole figure analysis also confirms the absence of phase separation. With these thin films Schottky photodiodes have been demonstrated with VIS-UV rejection ratios of 4 orders of magnitude and absorption edges all the way to 4.5 eV (fig. 6.2.7), making them potential candidates for solar blind photodetection.

Mg (%)	E_g (eV)	$n=N_d^+-N_a^-$ (10^{16} cm^{-3})	Ev+0.25eV (10^{16} cm^{-3})	Ev+0.55eV (10^{16} cm^{-3})
0	3.36	3.98	39.1	8.17
31	4.02	0.64	3.0	3.02
44	4.17	0.58	3.2	3.31
52	4.47	0.62	3.8	2.24
56	4.56	0.65	2.7	1.17

***Table 6.2.1**. Carrier concentrations and acceptor-like deep levels in $Zn_{1-x}Mg_xO$.*

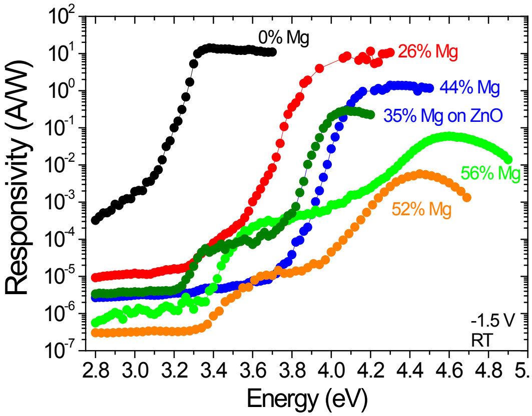

***Figure 6.2.7**. Spectral response of $Zn_{1-x}Mg_xO$ UV Schottky photodiodes.*

ZnMgO/ZnO MQW light polarization sensitive photodetectors. [6]

Light polarization-sensitive UV photodetectors (PSPD) using non-polar a-plane ZnMgO/ZnO multiple quantum wells (10x) grown by MBE both on sapphire and ZnO substrates have been developed and demonstrated (figs. 6.2.8 and 6.2.9). For the PSPDs grown on sapphire with anisotropic biaxial in-plain strain, the responsivity absorption edge shifts by ΔE~21 meV between light polarized perpendicular (⊥) and parallel (//) to the c-axis, and the maximum responsivity (R) contrast is $(R_\perp/R_{//})_{max}$~6. For the PSPDs grown on ZnO, with strain-free quantum wells, ΔE~40 meV and $(R_\perp/R_{//})_{max}$~5. These light polarization sensitivities have been explained in terms of the excitonic transitions between the conduction and the three valence bands, and present figures of merit (table 6.2.2) that set the state of the art for this technology.

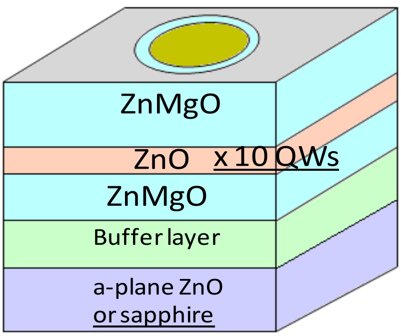

***Figure 6.2.8**. Structure of ZnMgO/ZnO MQWs photodetector and spectral response for unpolarized light.*

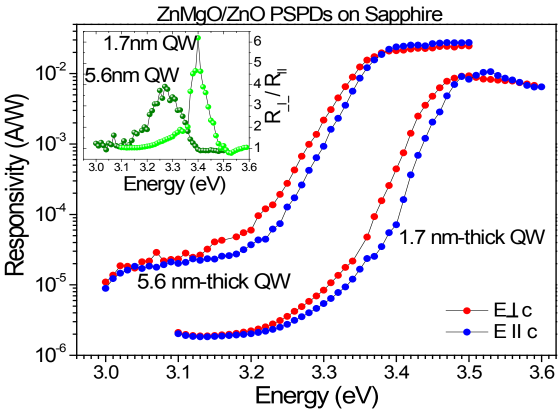

***Figure 6.2.9**. Spectral response for ZnMgO/ZnO MQW photodetectors for polarized light.*

Sample	Substrate	Experimental results		
		$E_{absorption}$ (eV)	$(R_\perp/R_{\|\|})_{max}$	PSBW (meV)
P1 (strained)	*r-Al$_2$O$_3$*	3.450 (E⊥c)	6.2	8
		3.471 (E||c)		
P2 (strained)		3.342 (E⊥c)	3.9	14
		3.361 (E||c)		
P3 (strain-free)	*a-ZnO*	3.317 (E⊥c)	4.8	12
		3.357 (E||c)		

***Table 6.2.2**. Figures of merit of PSPDs based on ZnMgO/ZnO MQWs.*

Acceptors in N-doped ZnMgO. [7]

A combination of deep level optical spectroscopy and lighted capacitance voltage profiling has been used to analyze the effect of N on the energy levels close to the valence band of $Zn_{0.9}Mg_{0.1}O$ grown by RPE-MOCVD (fig. 6.2.10). Three energy levels at E_V+0.47 eV, E_V+0.35 eV, and E_V+0.16 eV are observed in all films with concentrations in the 10^{15}-10^{18} cm^{-3} range. The two shallowest traps have very large concentrations that scale with the N exposure (table 6.2.3), and are thus potential acceptor levels. While the E_v+0.35 eV may be related to N_O, the E_v+0.16 eV may be linked to the N_O-V_{Zn} defect complex, shallower and thus much more efficient as an acceptor. In order to correctly quantify the trap concentrations, a metal-insulator-semiconductor model was invoked, explaining well the resulting capacitance-voltage curves.

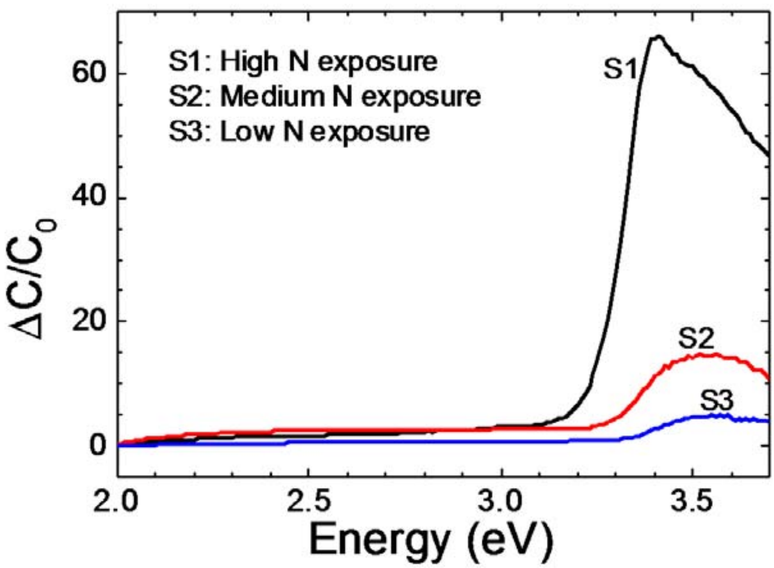

***Figure 6.2.10**. DLOS spectra of $Zn_{0.9}Mg_{0.1}O$:N films for different N exposures*

Trap	E_T-E_V (eV)	Sample S1 $\Delta C/C_0$	Sample S1 N_T(cm^{-3})	Sample S2 $\Delta C/C_0$	Sample S2 N_T(cm^{-3})	Sample S3 $\Delta C/C_0$	Sample S3 N_T(cm^{-3})
T1	0.16	?	?	9.5	5.45×10^{17}	1.85	2.06×10^{17}
T2	0.35	61.5	8.9×10^{18}	0.43	2.0×10^{16}	0.20	N.A.[a]
T3	0.47	0.17	5.8×10^{16}	0.04	6.0×10^{15}	0.01	N.A.[a]

[a] Not Available.

***Table 6.2.3**. Trap concentrations for the deep levels closer to VB in $Zn_{0.9}Mg_{0.1}O$:N.*

References

[1] M. Lopez-Ponce, A. Hierro, J. M. Ulloa, P. Lefebvre, E. Munoz, S. Agouram, V. Munoz-Sanjose, K. Yamamoto, A. Nakamura, and J. Temmyo, *Appl. Phys. Lett.* **102**, (2013).

[2] M. Lopez-Ponce, A. Nakamura, M. Suzuki, J. Temmyo, S. Agouram, M. C. Martínez-Tomás, V. Muñoz-Sanjosé, P. Lefebvre, J. M. Ulloa, E. Muñoz, and A. Hierro, *Nanotech*. **25**, 255202 (2014).

[3] K. Yamamoto, A. Nakamura, J. Temmyo, E. Muñoz, and A. Hierro, *IEEE Photon.Tech. Lett*. **23**, 1052 (2011).

[4] A. Redondo-Cubero, A. Hierro, J.-M. Chauveau, K. Lorenz, G. Tabares, N. Franco, E. Alves, E. Muñoz, *Crys. Eng. Comm.* **14**, 1637 (2012).

[5] E. Gur, G. Tabares, A. Arehart, J. M. Chauveau, A. Hierro, and S. A. Ringel, *J. Appl. Phys.* **112**, 123709 (2012).

[6] G. Tabares, A. Hierro, B. Vinter y J.-M. Chauveau, *Appl. Phys. Lett.* **99**, 071108 (2011).

[7] G. Tabares, A. Hierro, M. Lopez-Ponce, E. Muñoz, B. Vinter and J.-M. Chauveau, *Appl. Phys. Lett.* (2015).

[8] A. Kurtz, A. Hierro, E. Munoz, S. K. Mohanta, A. Nakamura, and J. Temmyo, *Appl. Phys. Lett.* **104**, 081105 (2014)

6.3 Ordered InGaN/GaN nanostructures for solid state lighting applications. Axial and core-shell nanorods [3]

Ana Bengoechea-Encabo, Steven Albert, Miguel A. Sánchez-García and Enrique Calleja

In the last years the activity of the semiconductor devices group (GDS) at ISOM focused on the growth of ordered InGaN nanostructures by plasma-assisted molecular beam epitaxy (PAMBE) taken as building blocks for the next generation of LEDs. Several nanocolumn-based approaches, such as InGaN/GaN axial and core-shell structures are presented. The PAMBE growth, as well as the characterization by SEM, PL, RT-CL and EL was performed at ISOM facilities, whereas the TEM analysis and STEM-CL was performed at Paul Drude Institute PDI (Berlin) and Otto-von-Guericke University (Magdeburg).

I. Selective area growth of axial InGaN/GaN nanocolumns on GaN/sapphire substrates

For device applications ordered InGaN/GaN nanocolumns (NCs) are better suited than their self-assembled counterpart because of their higher homogeneity in terms of dimensions, as well as optical and electrical properties. One way to achieve ordered NCs is the selective area growth (SAG) by PAMBE. Previous to SAG, the substrate must be patterned with a mask of nanoholes with the desired dimensions (diameter and distances). A Ti mask is fabricated either by electron-beam lithography combined with etching, or colloidal lithography combined with a lift-off process [1,2].

Selectivity was achieved for GaN NCs (one GaN NC per nanohole) under a narrow condition window where the Ga/N fluxes and growth temperature can be varied. Depending on the particular set of conditions chosen, the top most facet of the ordered NCs has pencil-like (finishing in semi-polar facets) shape or flat-top (finishing in polar c-planes) one, as shown in figure 6.3.1.

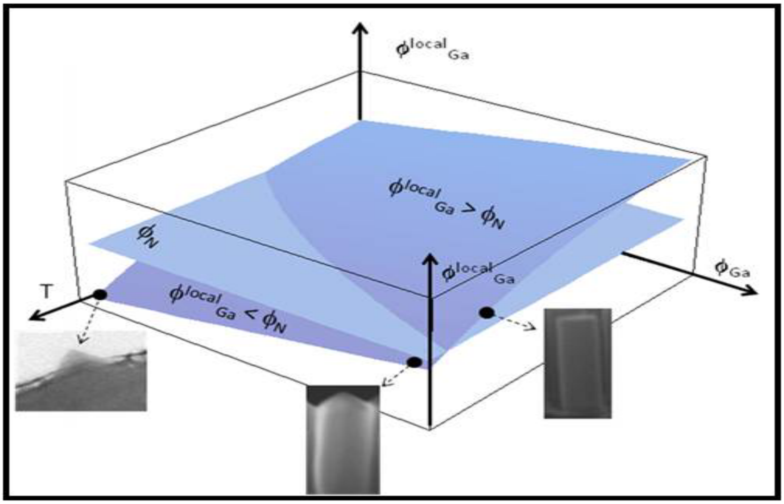

***Figure 6.3.1**. Effect of growth temperature and Ga-flux on the GaN NC top morphology during SAG; for a fixed Φ_N value, the ratio Φ^{local}_{Ga}/Φ_N (> 1 flat top, < 1 pencil-like top) is mainly controlled by growth temperature and impinging Ga flux (Φ_{Ga}).*

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Single InGaN nanodisks were embedded into the ordered NC types (pencil-like top and flat-top), and their structural and optical characteristics were studied by STEM and photoluminescence (PL) respectively.

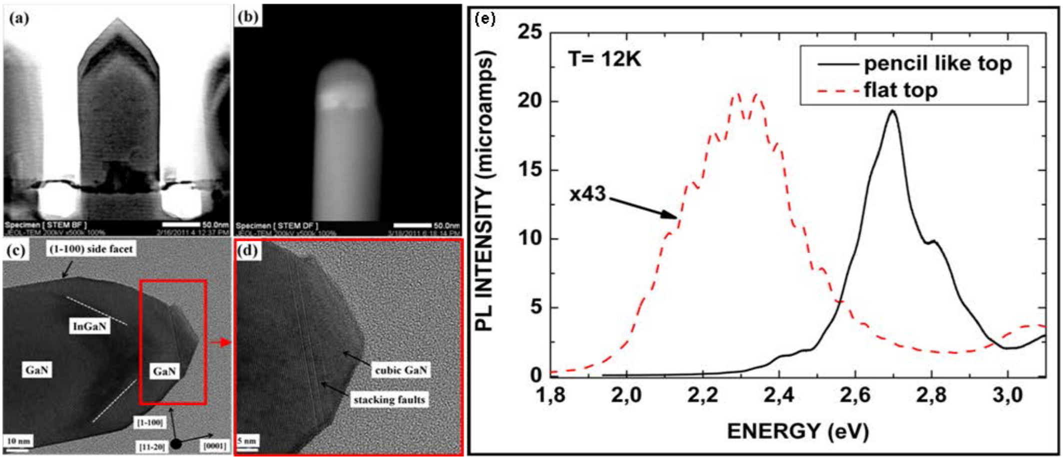

Figure 6.3.2. *(a) STEM bright-field image of InGaN nanoDisk embedded in GaN NCs with pencil like top; (b) HAADF-STEM image of an InGaN nanoDisk embedded in GaN NCs with flat top; (c) and (d) HRTEM images of embedded InGaN nanoDisks shown in (a); (e) LT-PL spectra of two GaN/InGaN/GaN ordered nanocolumnar heterostructures with InGaN regions having flat and pyramidal shape.*

As shown in figures 6.3.2.a and 6.3.2.b the morphology of the InGaN embedded nanodisks is determined by the top morphology of the GaN NCs underneath. Whereas true disk geometry is obtained in flat top NCs, an inverted V-shaped InGaN with semipolar planes occurs on pyramidal top NCs. The NCs structure is found to be free of extended defects but for the topmost GaN cap-layer, where stacking faults and cubic inclusions are found (figures 6.3.2.c and 6.3.2.d). The low temperature PL spectra shown in figure 2.e reveal a strong peak energy shift between the two samples (0.4 eV) which can be attributed to: i) different In% related to crystal planes, and/or ii) different strain states and internal electric fields, again related to the different character of polar and semipolar planes. The observed intensity differences, i.e. only 1/43 in case of the NCs with flat top, point towards a difference of the internal electric fields, which lead to a reduced oscillator strength and red shift in case of the flat top. Based on these findings it can be concluded that when using active structures grown on pyramidal top NCs for LEDs an improved device performance should be observed. For more details see reference [3].

Another approach is to grow ordered NCs with long InGaN sections (no disks) where crystal quality is preserved while avoiding the effects of internal electric fields and Quantum Stark effect. The In incorporation and distribution, both axial and radial, as well as the growth mechanisms were studied. Different color emission (blue, green, red) were optimized (In composition) to check a monolithic approach for phosphor-free white light emitters. The InGaN sections were grown with: i) nominally constant In composition aiming for red, green and blue emission, ii) In graded composition (not shown here) and iii) by stacking red, green and blue segments (RGB approach) in each individual NC. The last two approaches were developed aiming for white light emission.

In order to achieve emission in the blue, green, and red spectral range, InGaN sections were grown on top of GaN NCs using different growth conditions. The results are shown in figure 6.3.3.a. The findings for single color emission can be summarized as follows: i) the growth temperature and In/Ga ratio are the main factors to control the In composition in SAG InGaN/GaN NCs; ii) Ga and In diffusion along the NC sidewalls represent crucial contributions to the overall NC growth rate; iii) the NC top morphology of InGaN/GaN NCs is controlled by the actual local III/V ratio (flat to pencil like transition depending on the local III/V ratio on top of the NC), and iv) a composition gradient with an increasing In content towards the NC tip is observed in nominally fixed In% composition structures can be understood as due to a combination of InN decomposition/segregation, shadowing, and lattice pulling effects.

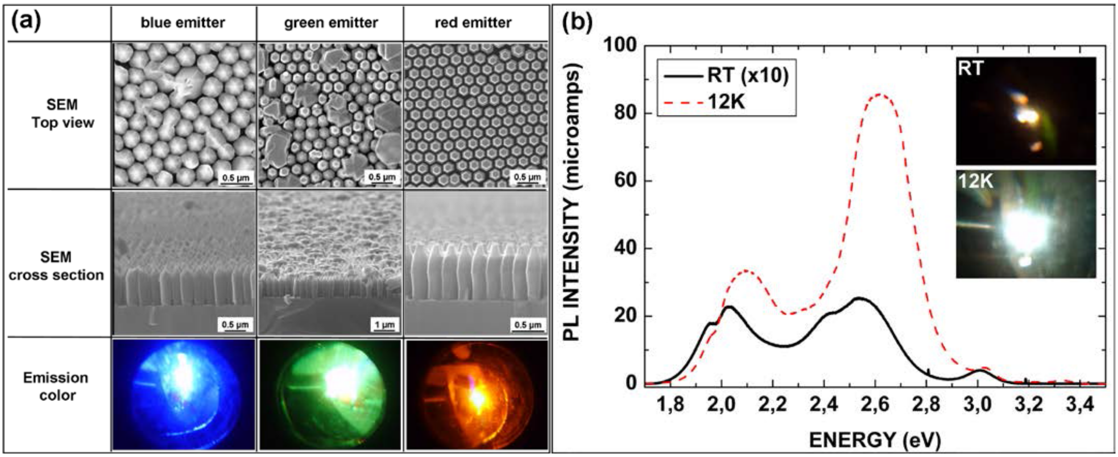

Figure 6.3.3. *(a) Top view SEM, cross-section SEM, and PL emission pictures from InGaN/GaN NCs; (b) Room- and low temperature (12K) PL spectra of RGB stacked sample.*

Figure 6.3.3.b shows LT and RT PL spectra of a RGB stacked sample, i.e. a sample where red, green and blue emitting InGaN sections are stacked in each NC.

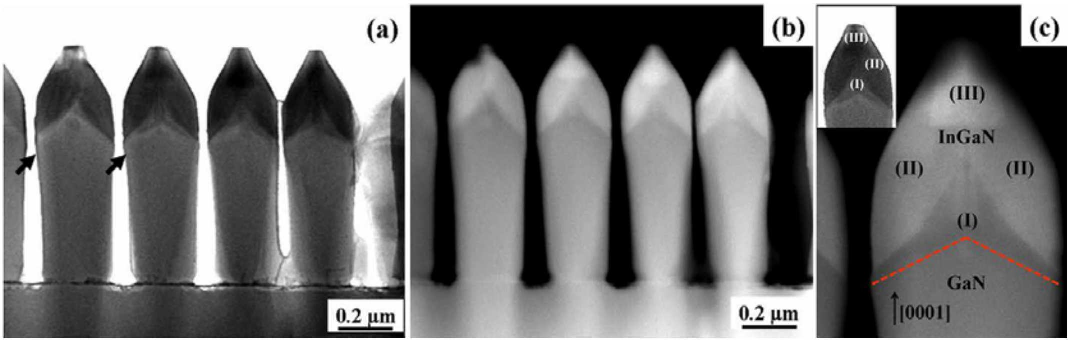

Figure 6.3.4. *(a) Bright-field STEM image of the NCs array of the RGB sample in cross-section, (b) corresponding HAADF Z-contrast image identifying the InGaN regions on the upper part of the columns. (c) Magnified part of the top area with the different InGaN regions marked by I, II, and III (inset: appropriate bright-field STEM of the NC; dashed line corresponds to GaN/InGaN interface).*

The structural investigation performed by TEM is shown in figure 6.3.4. The bright-field scanning STEM image in figure 6.3.4.a reveals the morphology of the NCs demonstrating their high uniformity in the pencil like shape and absence of threading dislocations or other extended defects in most observed NCs. The diameter is slightly increased (as indicated by the black arrows) at the transition region from GaN to the InGaN layer, which is identified by the dark strain contrast. The high-angle annular dark-field (HAADF) STEM imaging is applied in figure 6.3.4.b in order to resolve the different InGaN regions by observing an increase in bright contrast, which is directly correlated to the In content. In fact, three regions with distinct bright contrast can be identified and marked as (I), (II), and (III) in figure 6.3.4.c. The results of this section are published in references [4, 5]. Finally, axial NCs-based p-i-n (p-GaN/i-InGaN/n-GaN) LED-structures emitting in the blue, green and yellow colour, were fabricated and characterized by RT-EL, as shown in figure 6.3.5.

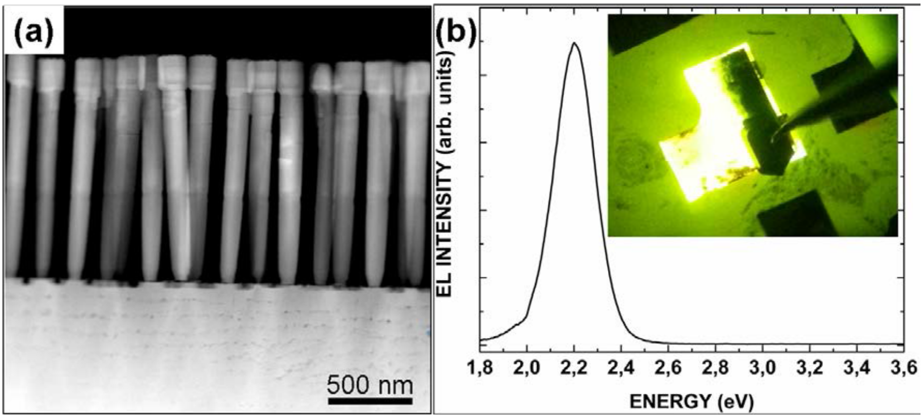

Figure 6.3.5*. (a) STEM picture of NC p-i-n LED structures, (b) EL spectrum of green a NC p-i-n LED (inset shows the working device).*

II. Selective area growth of axial InGaN/GaN nanocolumns on GaN/Si(111) substrates

After SAG on GaN/sapphire substrates, InGaN/GaN NCs were grown selectively on Si(111) substrates. To achieve SAG on Si(111) substrates, they must be GaN-buffered, since homoepitaxy is mandatory for SAG. High quality GaN buffers (without traces of yellow band), unintentionally doped (UID) and Si-doped, with a thickness between 120 nm and 720 nm, were grown by PA-MBE previous to the mask definition and the subsequent SAG. By changing the SAG conditions (III/V ratio and growth temperature), it is possible to cover the whole composition range from GaN to InN as shown in figure 6.3.6.

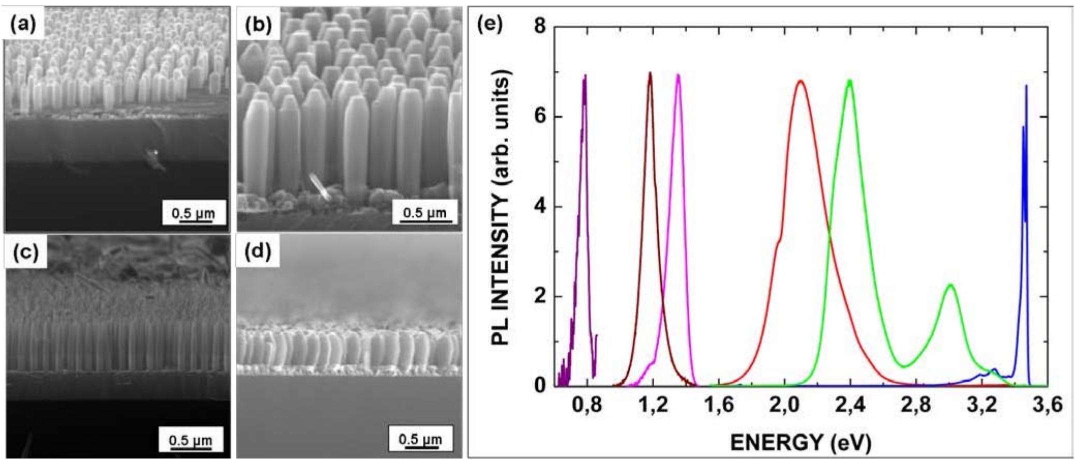

Figure 6.3.6*. Cross-section SEM images of (a) GaN NCs and (b)-(d) InGaN/GaN samples of different In content on GaN/Si(111) and (e) LT (12K) PL spectra of the InGaN/GaN samples with In contents between 0 and 100%.*

In addition, it has been shown that an increase of the In/Ga ratio improves the NC morphology (homogenous NC diameter), while a decrease of III/V ratio (higher Φ_N) sharpens the NC diameter along the growth direction (needle-like shape) and strongly increases the estimated internal quantum efficiency (by PL). In particular, for green emission optimized growth conditions lead to an efficiency increase from 3.3% to 36%. Most of the results on this topic have been published in reference [6].

III. Ordered InGaN core-shell microcolumns

Axial InGaN/GaN nanostructures are a feasible approach to fabricate efficient LEDs. However, there is a strong practical limitation due to the reduced emission area (NCs cross section) as well as the negative effects of the internal electric field. An alternative is to grow InGaN/GaN core-shell structures because of the enlarged emission area (sidewalls) and their non-polar character (m-planes). Core-shell InGaN/GaN microcolumns were grown following a top-down approach and PA-MBE overgrowth. In particular, they are based on the conformal growth of (In)GaN layers over etched GaN micropillars. The etched GaN micropillars were fabricated from GaN/sapphire templates, which were patterned with ordered Ni micro-disks (by photolithography and metalization) and subsequent etching down by inductively coupled plasma (ICP). The results have been published in reference [7].

STEM and SEM-CL confirmed the conformal InGaN/GaN growth on the GaN pillars (fig. 6.3.7). The In incorporation is found to depend strongly on the crystal plane involved, being much smaller for non-polar planes (sidewalls of the pillars) than for polar ones (top). In addition, the morphology and optical emission uniformity, similar to SAG InGaN/GaN axial structures, has been found.

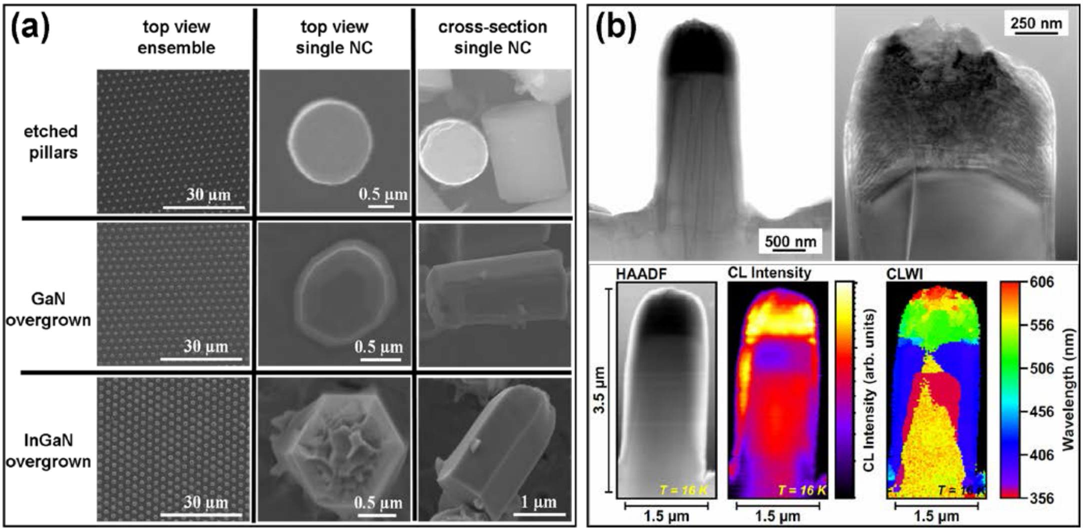

__Figure 6.3.7__. (a)top view and cross-section SEM pictures of etched GaN pillars as well as of GaN overgrowth and InGaN overgrowth on the pillars; (b) STEM-CL analysis at 16 K.

References

[1] A. Bengoechea-Encabo, F. Barbagini, S. Fernandez-Garrido, J. Grandal, J. Ristic, M.A. Sanchez-Garcia, E. Calleja, U. Jahn, E. Luna, A. Trampert, *J. Cryst. Growth* **325**,89 (2011).

[2] A. Bengoechea-Encabo, S. Albert, M.A. Sanchez-Garcia, L.L. López, S. Estradé, J.M. Rebled, F. Peiró, G. Nataf, P. de Mierry, J. Zuniga-Perez, E. Calleja, *J. Cryst. Growth* **353**, 1, 1-4 (2012).

[3] S. Albert, A. Bengoechea-Encabo, P. Lefebvre, F. Barbagini, M. A. Sanchez-Garcia, E. Calleja, U. Jahn, A. Trampert, *Appl. Phys. Lett.* **100**, 231906 (2012).

[4] S. Albert, A. Bengoechea-Encabo, M.A. Sanchez-Garcia, E. Calleja, U. Jahn, *J. Appl. Phys.* **113**, 114306 (2013).

[5] S. Albert, A. Bengoechea-Encabo, X. Kong, M. A. Sanchez-Garcia, E. Calleja, A. Trampert, *Appl. Phys. Lett.* **102**, 181103 (2013).

[6] S. Albert, A. Bengoechea-Encabo, M. A. Sanchez-Garcia, X. Kong, A. Trampert, E. Calleja, *Nanotechnology* **24**, 175303 (2013).

[7] S. Albert, A. Bengoechea-Encabo, M. Sabido-Siller, M. Müller, G. Schmidt, S. Metzner, P. Veit, F. Bertram, M. A. Sanchez-Garcia, J. Christen, E. Calleja, *J. Cryst. Growth* **392**, 5 (2014).

6.4 GaN ordered nanostructures on semi-polar and non-polar substrates [4]

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Most of the work on III-nitrides based LEDs and LDs focused on the growth along the polar [0001] direction. However, the internal polarization fields (spontaneous and/or piezoelectric) are very strong in heterostructures grown along this polar direction. The associated Quantum Confined Stark Effect (QCSE) affects detrimentally the internal quantum efficiency and causes a blue shift of the electroluminescence peak with increasing current, due to screening of the internal electric field. In order to reduce or even avoid this internal polarization field, growth on semipolar and non-polar crystal orientations has been suggested and demonstrated. Up to now, the best results have been obtained when growing on nonpolar or semipolar bulk substrates but due to limitations of bulk GaN substrates (in terms of size and price), heteroepitaxy on r-plane and m-plane sapphire has been the most common approach. This heteroepitaxial growth results typically in GaN templates with large density of Basal Stacking Faults, BSF ($>10^5$ cm^{-1}) and associated partial dislocations.

The SAG by PAMBE has been used to grow Ga(In)N nanostructures on semi-polar (11-22) and non-polar (11-20) GaN/sapphire substrates. Results on this topic are published in references [1, 2].

I. Selective area growth on non-polar (11-20)GaN/sapphire substrates

Previous to the SAG, Ti nanohole masks by colloidal lithography were deposited on MOVPE (11-20) GaN/sapphire substrates (supplied by Dr. Jesus Zuñiga's group at CHREA-CNRS) [1]. Under SAG conditions, GaN nucleates selectively on the nanoholes (typical diameters between 100 - 250 nm) and the formed nanostructures develop further in-plane elongation along the [0001] direction (fig. 6.4.1). There is a preferential growth direction along the c-plane that in this case is parallel to the surface, thus, leading to the nanostructures merging.

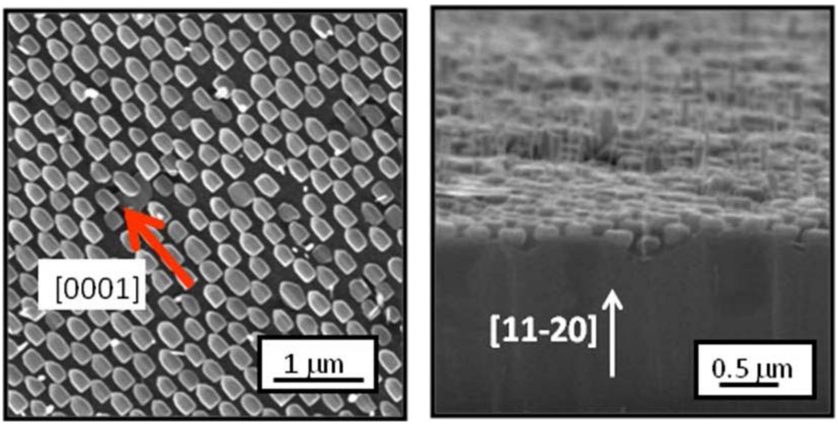

***Figure 6.4.1**. SEM images (top view and cross section) of SAG of GaN on (11-20) GaN/sapphire substrate. The arrow-like structures are visible, being oriented along the [0001] direction, parallel to the surface plane.*

PL results demonstrated the improvement on crystal quality after SAG compared with the original GaN template on sapphire. The Yellow Band emission signature, at around 2.3 eV, is observed by PL in the GaN template but is not seen in the nanostructures grown (fig. 6.4.2.a). The PL emission that peaks at 3.42 eV corresponds to BSFs present in the GaN template that propagate into the nanostructures. However the peak 3.472 eV (D^0X) indicates the formation of strain free, high quality material (fig. 6.4.2.b).

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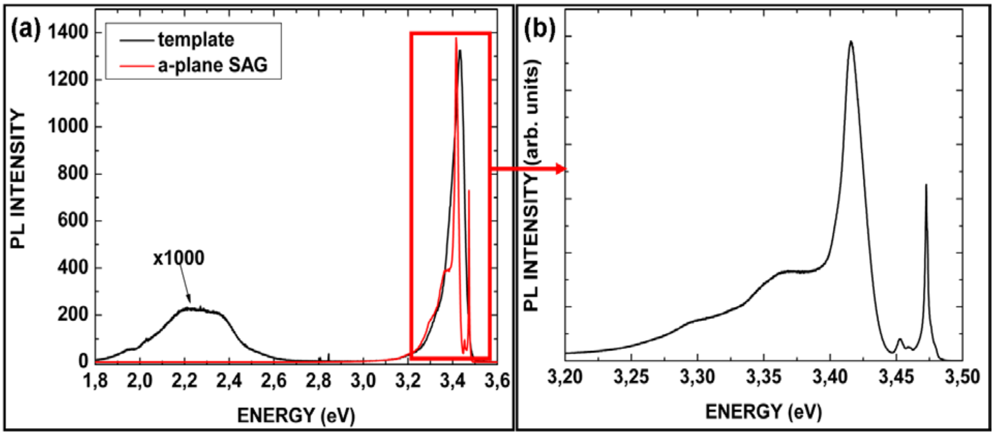

***Figure 6.4.2**. Low temperature (7K) PL spectra of: (a) GaN template and SAG GaN nanostructures grown on a-plane templates and (b) high resolution PL spectrum of the SAG GaN nanostructures.*

The use of a mask with a small distance between the nanoholes (typical diameters around 250 nm, and pitch – distance between centers – around 280 nm) facilitates the lateral coalescence of the nanostructures grown by SAG that develop into a continuous film of significantly improved quality (fig. 6.4.3.a-c).

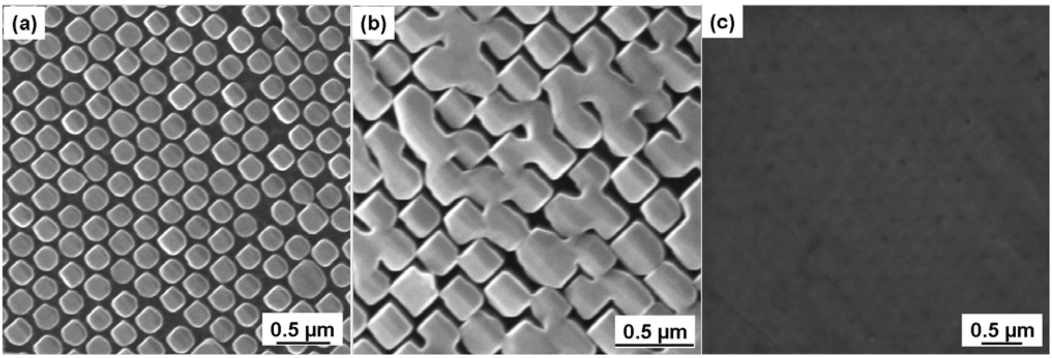

***Figure 6.4.3**. Top view SEM picture of GaN nanosctructures grown on (11-20) GaN/sapphire templates, showing different degrees of coalescence (a) well separated;(b) partially coalesced, (c) fully coalesced.*

II. Selective area growth on semi-polar (11-22) GaN/sapphire substrates

Ti nanohole masks for SAG were prepared by colloidal lithography on Ga(11-22)/sapphire substrates (provided by a collaboration with Dr. Jesus-Zuñiga's group at CRHEA-CNRS). Under SAG conditions for GaN growth, we obtained nanostructures with an elongation along [0001] direction, so tilted around 32º from the substrate surface (fig. 6.6.4.a and 6.6.4.b). TEM measurements (performed by Dr. Achim Trampert's group at Paul Drude Institute in Berlin) give information on the facets exposed to the molecular beams, i.e. polar, semi-polar, and non-polar planes. In addition, most of the GaN nanostructure volume after SAG is free of defects because the BSFs coming from the substrate (very high density) are effectively "filtered" leaving the upper part of the nanostructures free of them, as observed in figure 4c.

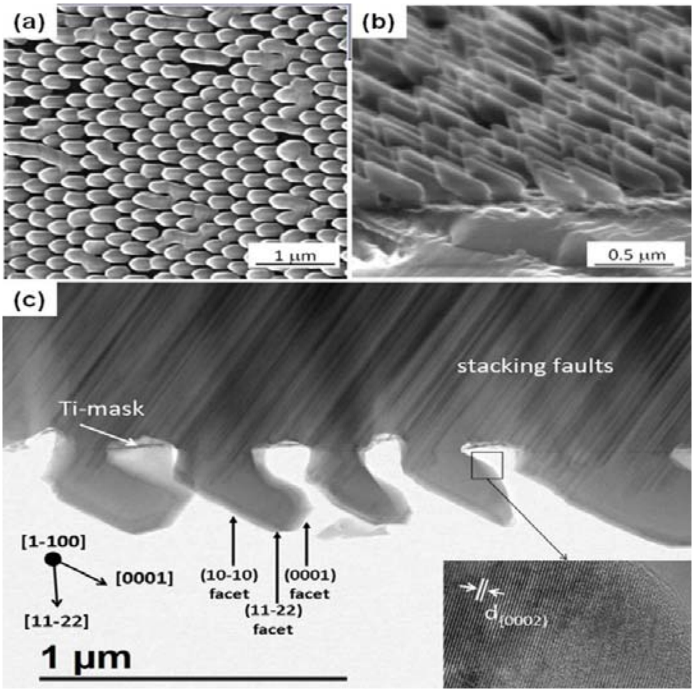

Figure 6.4.4. *SEM images of the ordered GaN nanostructures on a semi-polar (11–22) GaN template: top- (a) and bird's-eye (b) views. In (c), TEM image showing the tilted NCs with the long axis being parallel to the Ga-polar [0001] direction, and the filtering effect of the stacking faults from the template. The three facets exposed to the molecular beams are indicated in the figure. Results published in reference [2].*

The improvement in structural quality is accompanied by a strong enhancement of the PL emission efficiency (fig. 6.4.5). A quite broad featureless spectrum peaking at 3.43 eV is measured in the (11-22) GaN/sapphire template, which is commonly assigned to BSFs. After GaN NCs SAG a strong and narrow (FWHM of only 2.7 meV) near band emission at 3.473 eV, identified as strain-free D^0X, is observed. In addition, a weak emission at 3.42 eV, originating from BSFs, is still detected, probably originating from the template or the nanostructures bottom part.

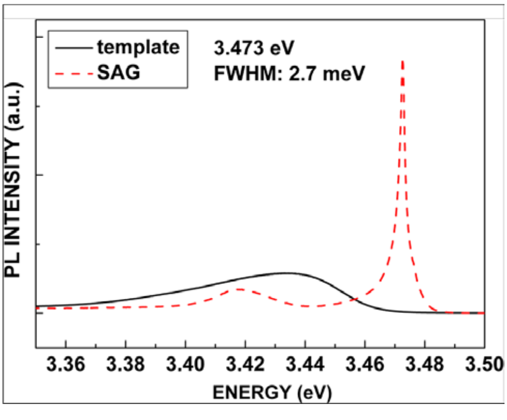

Figure 6.4.5. *Low temperature (8 K) PL spectra of the bare (11–22) GaN/sapphire template and after SAG of GaN NCs, reflecting the improvement in crystalline quality of the material.Results published in reference [2].*

The insertion of an InGaN thin section (kind of nanodisk) on the ordered tilted GaN nanostructures was also performed (fig. 6.4.6.a and 6.4.6.b). Since the ordered nanostructures have different facets exposed to the molecular beams during the growth, InGaN is grown consequently on different facets resulting in different In compositions depending on the specific facet considered. In particular two InGaN related emissions, at 2.43 eV and 3 eV, were found (besides a third one related to the near band emission of GaN). Spatially resolved CL results, revealed that the lowest energy InGaN related peak (2.43 eV) originates from the apex (growth along the c-direction), while the peak at 3 eV comes mostly from the nanostructure upper region which corresponds to the non-polar (10-10) plane (fig. 6.4.6.c and 6.4.6.d). Assuming strain-free InGaN, In-compositions of 26% and 10% can be estimated for polar and non-polar planes.

Although different InGaN regions inside a single nanostructure are present, the optical emission among different nanostructures is very homogeneous. That has been proven by comparing the CL spectrum of a single nanostructure with that of an ensemble with more than 2000 of them, as shown on figure 6.4.6.e.

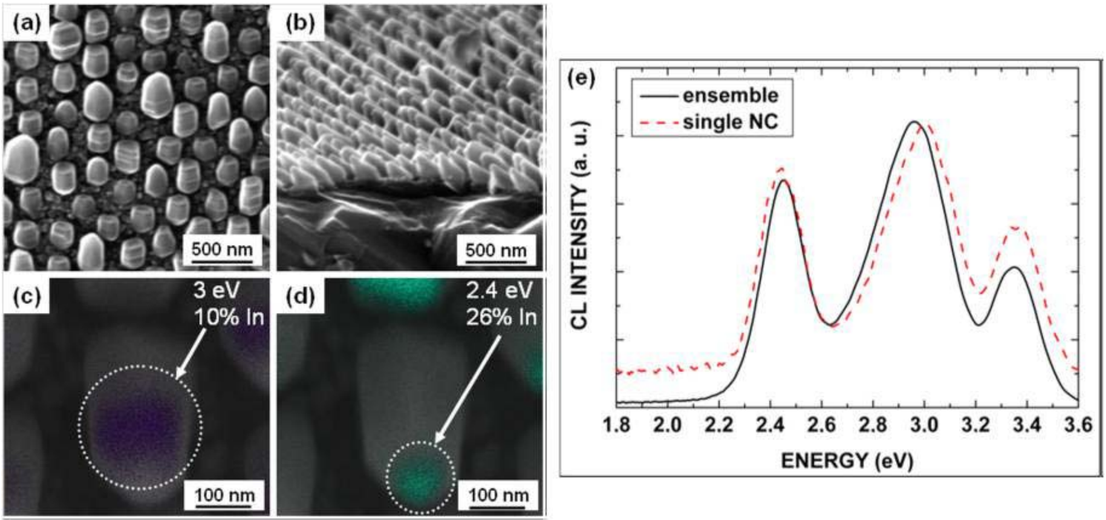

***Figure 6.4.6**. SEM pictures of InGaN/GaN nanostructures in top view (a), and bird view (b). Spatially resolved InGaN-related emissions are shown in the SEM-CL measurements in (c) and (d). In (e), comparison of RT-CL spectra of a single InGaN/GaN nanostructure and an ensemble of around 2000 InGaN/GaN nanostructures. Results published in reference [2]*

References

[1] A. Bengoechea-Encabo, S. Albert, M.A. Sanchez-Garcia, L.L. López, S. Estradé, J.M. Rebled, F. Peiró, G. Nataf, P. de Mierry, J. Zuniga-Perez, E. Calleja, *J. Cryst. Growth* **353**, 1 (2012).

[2] A. Bengoechea-Encabo, S. Albert, J. Zuñiga-Perez, P. de Mierry, A. Trampert, F. Barbagini, M. A. Sanchez-Garcia, E. Calleja, *Appl. Phys. Lett.* **103**, 241905 (2013).

6.5 Ordered GaN/InGaN/GaN Nanowires as Arrays of Single Photon Sources [5]

Zarko Gacevic and Enrique Calleja

The fastest triggered single-photon sources (SPS) to date have been demonstrated using epitaxially grown semiconductor quantum dots (QDs) [1]. The big advantage of semiconductor QDs is that they can be relatively easily tuned in respect to alternative SPS systems (such as: atoms, ions, molecules, nitrogen-vacancy centers and colloidal quantum dots) and conveniently integrated with optical microcavities [2]. Recent advances in QD technology, including demonstrations of room temperature (RT) SPS, electrically driven SPS as well as telecommunication wavelength SPS, have reduced the gap between demonstrations and practical applications [3-5].

An InGaN QD [6] embedded into a GaN nanowire (NW) is an excellent candidate for the realization of efficient, flexible and scalable SPS-based optoelectronic systems. The embedding of a QD into a NW facilitates the posterior SPS integration into optoelectronic circuits, since it can be easily transferred from its native to a foreign substrate. The emission of an InGaN QD can be tuned from near UV to near infra-red, via InGaN composition variation. Consequently, the wavelength of single photons can be easily adjusted to those wavelengths that are used in optical fiber (silica or plastic-based) and/or free-space communications. The temperature range operation of InGaN QD based SPS can be controlled via depth of confinement, i.e. via employment of AlGaN barriers. High Al content AlGaN barriers are convenient for RT SPS operation, as recently demonstrated [5]. The SPS frequency range can be manipulated via QD electron/hole wavefunctions overlapping, i.e. the QD electron-hole pair lifetime. In particular, cubic (zinc-blende) (In)GaN QDs are convenient for high frequency applications (GHz range), as recently reported [7]. Finally, the GaN-based material systems are characterized by high chemical and thermal stability, as well as with a large breakdown voltage.

In the last years, the group of semiconductor devices at ISOM focused on the growth of ordered GaN/InGaN/GaN NW arrays for SPSs, emitting in the visible range. The incorporation of an InGaN very thin later inside a GaN NW structure leads to the formation of controllable QD states. The formed QDs behave as SPSs. The realization of arrays of site-controlled SPSs, on a single substrate, opens the door for an on-chip quantum information networking, enabling quantum information processing.

I. Growth of Ordered Arrays of Dot-in-Wire Structures

Ordered arrays of dot-in-wire objects are fabricated on (0001)GaN-on-sapphire templates using nano-hole masks prepared by colloidal lithography [8]. The NWs are grown in hexagonal arrays with a pitch of 270 nm. They are characterized with highly uniform diameters and heights (around 180 and 500 nm, respectively) and with pyramidal tops. The InGaN portions, with In content around 20% and thickness between 5 and 25 nanometers, are grown on the top of GaN NWs followed by 20 nm GaN capping. Scanning electron microscopy (SEM) confirms the growth of ordered arrays of NWs with uniform morphology (fig. 6.5.1).

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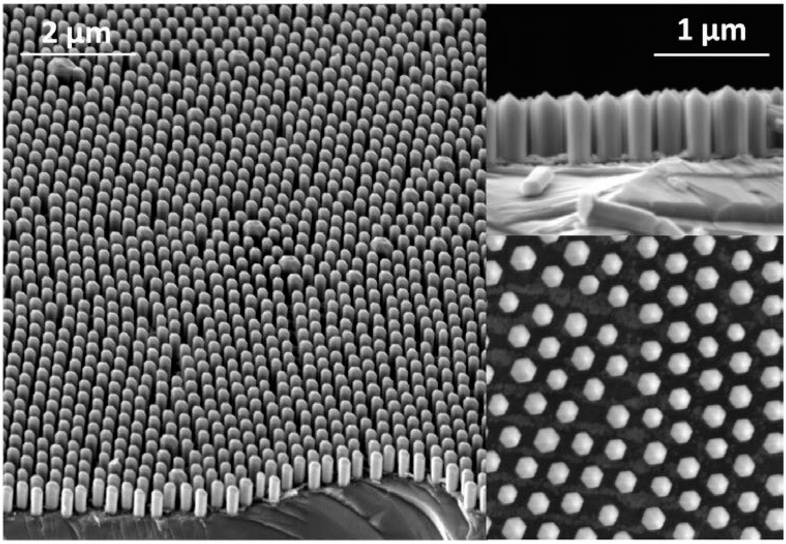

Figure 6.5.1. *Ordered array of dot-in-wire objects, as seen by high resolution SEM: birdeye-, cross- and top-view.*

II. Optical Properties of Ensembles of Dot-in-Wire Objects

Ultra-violet PL performed on NW ensembles with a laser line of 325 nm, with a probe size of ~1 mm^2, (around 20 million NWs excited at once) reveal two InGaN related emissions, a low-energy one, typically centered around 500 nm (green luminescence) and a high-energy one, typically centered around 400 nm (violet luminescence) as can be seen in figure 6.5.2.

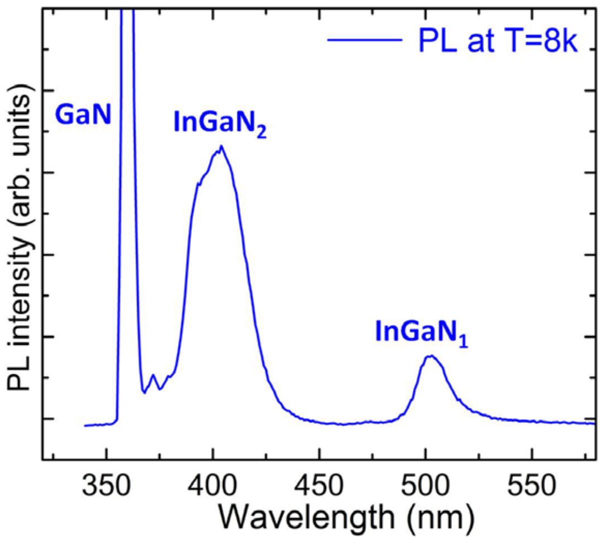

Figure 6.5.2. *PL emission of an ensemble of ordered dot-in-wire objects (around 2×10^7 NWs excited). Two InGaN-related emission bands are clearly resolved. These bands are tightly related to the c-plane and r-plane NW facets.*

To determine the origin of the two emission bands, a combination of spatially and spectrally resolved measurements has been performed (fig. 6.5.3). RT SEM-CL measurements reveal that the green luminescence is coming from the NW tip. Low temperature (15 K) TEM-CL measurements further confirm that the violet luminescence comes from the side NW facets. The two emission bands are tightly related to the two nano-facets involved in the system, the *c*-plane and the *r*-plane one; the excitons created at the polar *c*-plane recombine with lower energy, yielding green emission, whereas those created at semi-polar *r*-plane recombine with higher energy yielding violet emission.

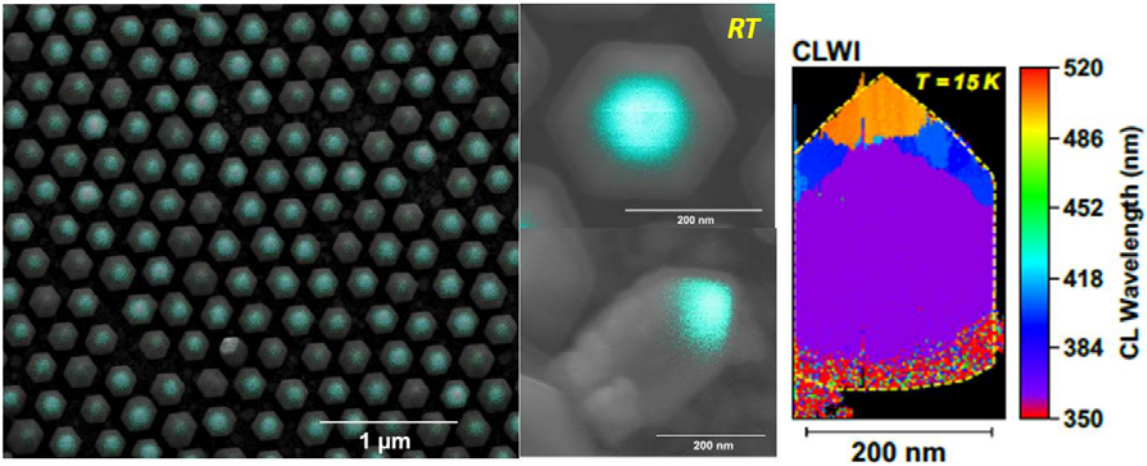

Figure 6.5.3*. CL emission of single dot-in-wire objects. Room temperature, SEM-CL measurements reveal that the green luminescence is coming from the NW tips. Low temperature TEM-CL reveals that the violet luminescence comes from the side facets. The low and high energy emission bands are tightly related to the two nano-facets: the polar (c-plane) and the semi-polar (r-plane) one. (Measurements performed at theUniv. of Magdeburg by Prof. J. Christen´s group).*

III. Single Nanowire Spectroscopy

The typical separation of the grown dot-in-wire objects is around 270 nm, a value significantly lower than the size of micro PL probes (0.5 – 3 µm). To achieve single NW spectroscopy the NWs are transferred from their native to foreign Si substrates. In addition, to achieve precise NW coordination and allow for multiple measurements of the same NW, a Ti lithographic mask is previously nano-imprinted on the Si surface by electron beam litography.

Each Ti mask covers 3×4 mm^2 area, and contains 23×17 matrices, designated with a number/letter combination. Each matrix is composed from 9×9 (even lines) or 11×11 (odd lines) micro-squares. Figure 6.5.4 shows one matrix (designated as 9-G) of the Ti mask, after the NW transfer has been performed, as seen by optical and scanning electron microscopy. Single NWs are spotted by high resolution SEM (insets) and then analyzed by micro-PL. The dashed circles represent approximate size of the probe, used in micro-PL experiments.

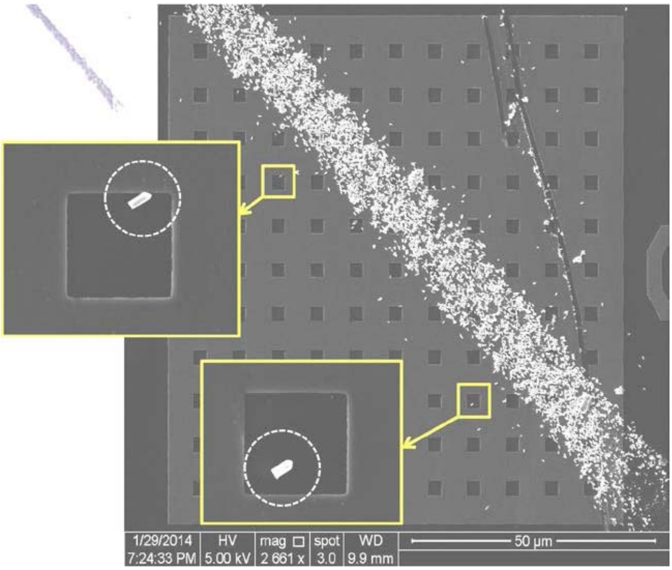

***Figure 6.5.4**. (Left-up) An image of 9-G matrix of Ti mask printed on a foreign Si substrate, after the NW transfer has been performed. (Right) High-resolution SEM image of the same area, with the illustration of the procedure for single NWs spotting; the coordinates of the two spotted single NWs are thus: 9-G/[4,3] and 9-G/[9,8], respectively.*

IV. Spotting and Measurement of Single Photon Emission Centers

The spotted single NWs are put into thorough micro PL inspections. The micro PL technique allows identification of candidates for single photon emission (SPE) centers. Figure 6.5.5 illustrates spotting of four candidates for SPE. These four centers are all contained at the tip of the same NW, located next to the 9-G/[6, 11] micro-square.

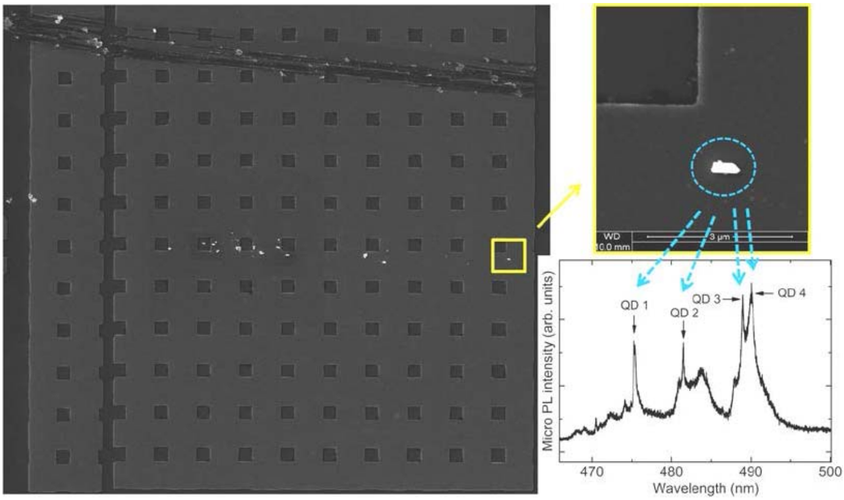

***Figure 6.5.5**. Spotting of single photon emitters on the sample surface. Four candidates for SPS are spotted. They originate from the tip of the NW located next to [6, 11] a micro-square (9-G matrix).*

The number of SPS centers per single NW typically varies between zero (≥ 0) and few (≤ 5). A certain fraction of inspected NWs contains exactly one SPS center. Figure 6.5.6 (left) shows emission of such a center. This center exhibits intense and narrow (<500 μeV) emission. Photon correlation measurement, performed on this emission center using a Hanbury Brown and Twiss interferometer (Fig. 6.5.6 (right)) shows pronounced antibunching. The $g^{(2)}(0)$ value found at ~0.2 (after correction for the instrumental time response and background noise) is a clear signature of single photon emission.

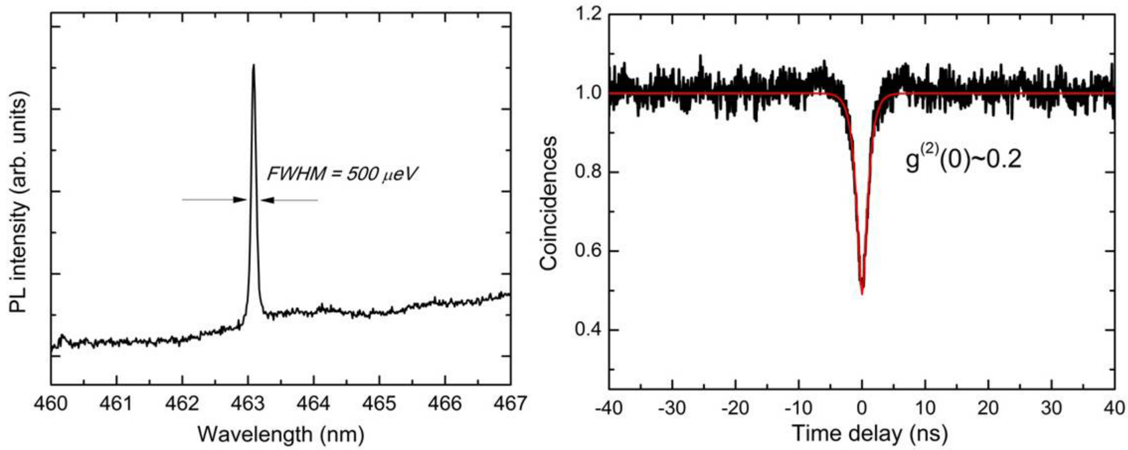

Figure 6.5.6. *(Left) μ-PL spectrum of single NW reveals intense and narrow single QD emission line. (Right) Photon correlation measurement performed on this emission center shows a pronounced antibunching $g^{(2)}(0) \sim 0.2$. This value is a clear signature of single photon emission. Solid line is a theoretical fit to an instrumental response-convoluted second-order correlation function $g^{(2)}(\tau)$.*

References

[1] S. Buckley, K. Rivoire, and J. Vučković, *Rep. Prog. Phys*. **75**, 126503 (2012).

[2] Ž. Gačević, G. Rossbach, R. Butté, F. Réveret, M. Glauser, J. Levrat, G. Cosendey, J.-F. Carlin, N. Grandjean, and E. Calleja, *J. Appl. Phys.* **114**, 233102 (2013).

[3] S. Kako, C. Santori, K. Hoshino, S. Götzinger, Y. Yamamoto, and Y. Arakawa, *Nature Materials* **5**, 887 (2006).

[4] S. Deshpande, J. Heo, A. Das, and P. Bhattacharya, *Nat. Commun*. **4**, 1675 (2013).

[5] M. J. Holmes, K. Choi, S. Kako, M. Arita, Y. Arakawa, *Nano Lett*. **14**, 982 (2014).

[6] Ž. Gačević, A. Das, J. Teubert, Y. Kotsar, P.K. Kandaswamy, Th. Kehagias, T. Koukoula, Ph. Komninou, and E. Monroy, *J. Appl. Phys*. **109**, 103501 (2011).

[7] S. Kako, M. Holmes, S. Sergent, M. Bürger, D. J. As, and Y. Arakawa, *Appl. Phys. Lett.* **104**, 011101 (2014).

[8] A. Bengoechea-Encabo, S. Albert, M.A. Sanchez-Garcia, L.L. López, S. Estradé, J.M. Rebled, F. Peiró, G. Nataf, P. de Mierry, J. Zuniga-Perez, and E. Calleja, *J. Crystal Growth* **353**, 1 (2012).

6.6 Nanostructured materials for optical biosensing [6]

Carlos Angulo Barrios

Optical transducers based on submicro- or nano-structured materials may lead to significant improvements in terms of sensitivity, selectivity, mass transfer and binding kinetics as compared to those based on macro- or non-structured materials. This is due to their unique optical properties at the nanoscale and large surface-to-volume ratio. Additional advantages arise if nanostructured optical transducers are made of Si-based materials and polymers. These benefits include low cost, remarkable engineering possibilities and well-known surface functionalization chemistry. Over the last years, ISOM remarkable achievements on this field have been focused on three subjects that can be summarized as follows.

I. Submicron patterning of molecularly imprinted polymers

Recognition elements in biochips and biosensors are typically biomacromolecules such as enzymes, antibodies or DNA. These molecules specifically recognize and bind target molecules offering high selectivity against non-specific binding. However, they require low-temperature conservation and restricted operating conditions, which limits their usefulness, particularly for portable systems. Biomimetic receptors like molecularly imprinted polymers (MIPs) are an attractive alternative as synthetic receptors. MIPs are created by a templating process at the molecular level. They are able to bind target molecules with similar affinity and specificity to those of their natural counterparts. MIPs offer a number of advantages such as superior stability when exposed to solvents and temperature extremes, the feasibility of creating receptors for a variety of molecular structures, and good engineering possibilities.

Electron beam lithography (EBL) is the most popular nanolithography technique. EBL can generate arbitrary patterns with nanometer resolution without the need of moulds or contact masks. Therefore, EBL is a non-contact technique that avoids contamination of the surface to be patterned. Motivated by these remarkable advantages, it has been demonstrated for the first time electron-beam direct patterning of MIP films [3]. For this, a linear copolymer, poly(methacrylic acid-co-2-methacrylamidoethylmethacrylate (P(MAA-co-MAAEMA)) was synthesized, containing both, specific recognition groups (-COOH), for non-covalent binding interactions with template molecule bearing complementary functionalities, and triggerable cross-linkable groups for electron irradiation sensitivity. Thin films of this material, spun on Si substrates, exhibited positive-tone behaviour for both EBL (in the dose range 0.1 – 8 mC/cm^2) and DUV (255 nm wavelength) photolithography, and high sensitivity and selectivity towards the template molecule R123. The two-fold functionality of the developed linear copolymer as a recognition material and an EBL resist opens new opportunities in the implementation of innovative, nanostructured MIP film-based arrays for multiple target detection (fig. 6.6.1).

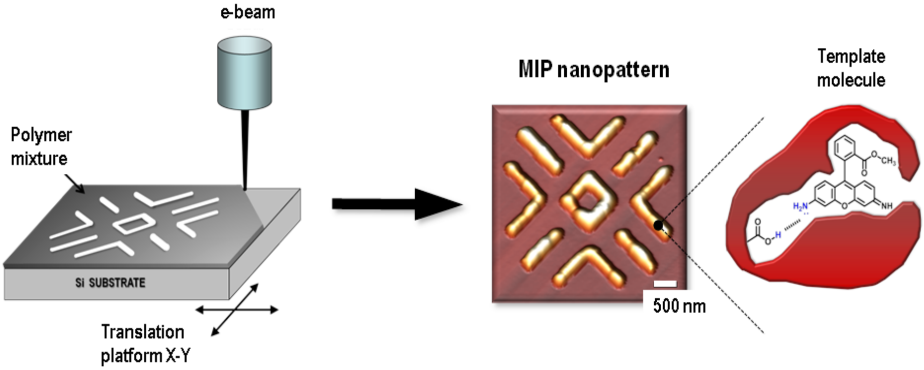

***Figure 6.6.1**. A nanopattern is directly written by EBL in a film of the synthesized polymer mixture, spun on a Si substrate. The mixture behaves as a positive tone EBL resist and the resulting feature acts as MIP capable to recognize the template molecule, R123, with high sensitivity and selectivity.*

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In addition, patterning of MIP films was carried out with minimum features of approximately 1 μm via microtransfer molding based on SiO_2/Si molds, fabricated by using standard microfabrication techniques. MIP patterns consisted of two-dimensional diffraction gratings (fig. 6.6.2) that were successfully used as label-free optical bio(mimetic)sensors for specific recognition of a fluoroquinolone antimicrobial, enrofloxacin, broadly applied in human and veterinary medicine [9,10].

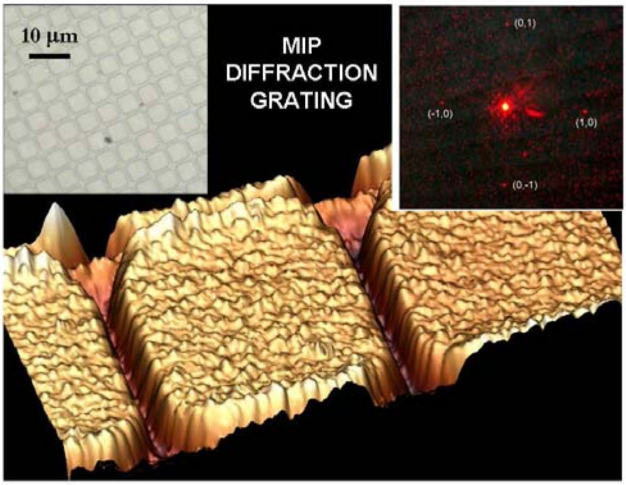

Figure 6.6.2*. Atomic force microscope image and cross-section scan of a representative portion of a MIP 2D grating. Left inset: optical microscope photograph of the micropatterned MIP film. Right inset: far-field diffraction pattern of a MIP 2D-DG immersed in water.*

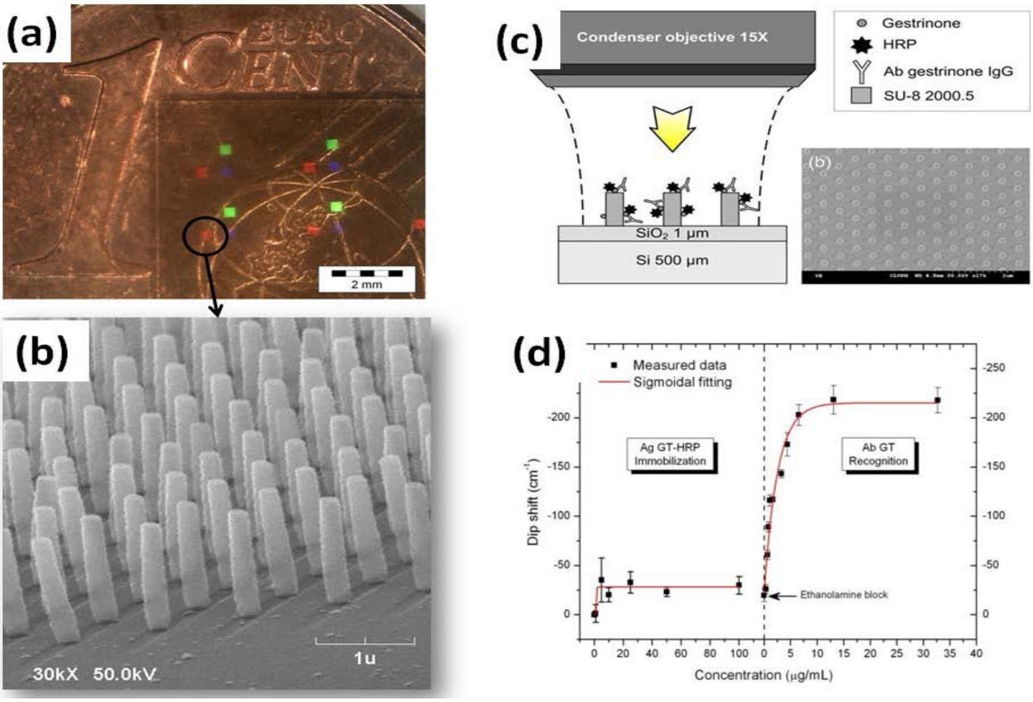

Figure 6.6.3*. (a) Optical image of SU-8 nanopillar lattices on an ITO/glass substrate in comparison with 1euro cent coin. (b) SEM image of a SU-8 nanopillar lattice. (c) Schematic diagram of the optical interrogation set-up. (d) HRP-h-G immobilization and anti-gestrinone antibody recognition.*

II. Nanopillar array biosensors

Periodic lattices of SU-8 resist nano-pillars on both SiO_2/Si and ITO/ SiO_2 substrates were fabricated (fig. 6.6.3). These lattices were used as interrogation platforms for BSA/antiBSA in buffer solution and gestrinone/antigestrinone in whole serum immunoassays. Affinity reactions on the pillar surfaces produce optical thickness changes that are detected by monitoring the surface platform reflectance (SiO_2/Si substrates) and/or transmittance (ITO/SiO_2 substrates) interference spectra variations. Detection limits below 1 ng/ml where measured [8,11,16,18].

III. Aluminium nanohole arrays for label-free optical biosensing

Optical techniques based on surface plasmon resonance (SPR) have been shown to be of great success for label-free biosensing applications. SPR systems based on prism-coupling are commercially available. Metallic nanostructures provide new design and integration possibilities which can lead to improvements in key SPR-based biosensor issues such as sensitivity, resolution, multiplexing and biological interfacing. In particular, nanohole arrays based chemical and biological sensors offer numerous applications and display great performance, and recent progresses aim to cheaper fabrication methods.

Noble metals Au and Ag are typically used in the fabrication of nanohole array SPR devices because of their low optical losses in the visible and near-infrared ranges. In addition, Au is highly chemically stable making it convenient for biological media. However, the high cost of these metals limits large scale commercialization of these sensors. Al is a more cost-effective plasmonic material: approximately 25,000 times and 425 times cheaper than Au and Ag, respectively. However, Al has been scarcely considered for the implementation of SPR biosensors mainly because of challenges from oxidation and material degradation.

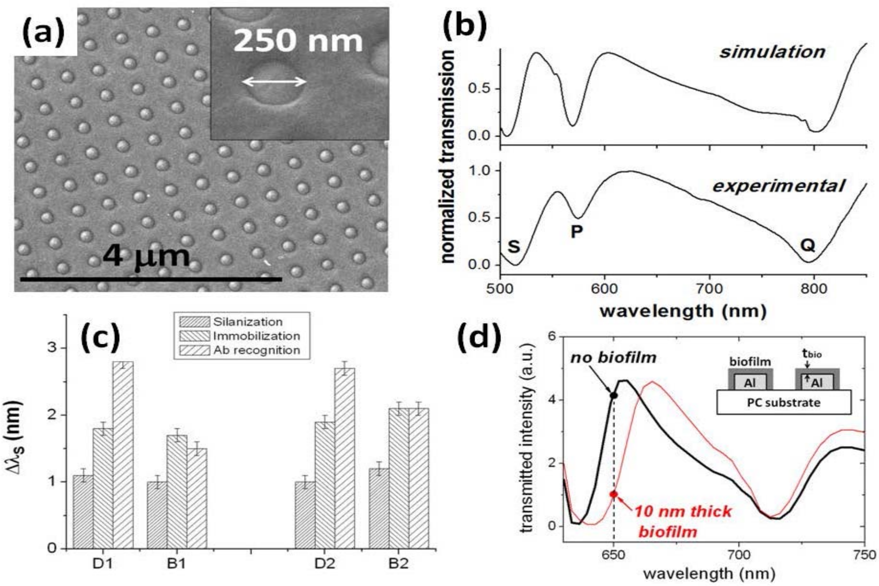

Figure 6.6.4. *(a) SEM photograph of a 500 nm pitch Al nanohole array on a PC substrate. (b) Experimental and calculated spectra of the Al nanohole array. Surface plasmon polariton features are observed (S,P and Q). (c) S-wavelength shift for direct and competitive assays carried out on the Al nanohole arrays. (d) Simulated transmitted intensity spectra of a 630 nm period Al nanohole array on PC substrate with a 10 nm thick biofilm (red line) and without a biofilm (black line). Inset shows a schematic cross-section of the simulated nanohole array along the middle of a hole row.*

It is shown that Al can be made a suitable and reliable plasmonic material for implementing nanohole array SPR biosensors. The issue of Al oxidation is tackled by a passivation process consisting of exposing Al nanohole array films to O_2 plasma [1]. This treatment produces a robust protecting oxide layer that is more resistant than native oxide against oxidizing agents like aqueous solutions or buffers usually employed in biosensing tests, thus avoiding corrosion and pitting issues. Thus Al nanohole arrays fabricated on both glass and polycarbonate (PC) [2] (for compact disc based biosensing platforms) substrates were fabricated and demonstrated their workability as label-free optically interrogated biosensors via bioassays based on biotin analysis through biotin-functionalized dextran-lipase conjugates immobilized on the biosensor passivated surface in aqueous media (fig. 6.6.4).

References

[1] Víctor Canalejas-Tejero, Sonia Herranz, Alyssa Bellingham, María Cruz Moreno-Bondi and Carlos Angulo Barrios, *ACS Applied Materials and Interfaces* **6**, 1005 (2014).

[2] C.A. Barrios, V. Canalejas-Tejero, S. Herranz, M.C. Moreno-Bondi, M. Avella-Oliver, R. Puchades and A. Maquieira, *Plasmonics* **9**, 645 (2014).

[3] S. Carrasco, V. Canalejas-Tejero, F. Navarro-Villoslada, C.A. Barrios and M.C. Moreno-Bondi, *J. Materials Chemistry C* **2**, 1400 (2014).

[4] F.J. Ortega, M.J. Bañuls, F.J. Sanza, M.F. Laguna, M. Holgado, R. Casquel, C.A. Barrios, D. López-Romero, A. Maquieira and R. Puchades, *J. Materials Chemistry B* **1**, 2750 (2013).

[5] V. Canalejas-Tejero, S. Carrasco, F. Navarro-Villoslada, J.L.G. Fierro, M.C. Capel-Sánchez, M.C. Moreno-Bondi and C.A. Barrios, *J. Materials Chemistry C* **1**, 1392 (2013).

[6] C.A. Barrios, S. Carrasco, V. Canalejas-Tejero, D. López-Romero, F. Navarro-Villoslada, M.C. Moreno-Bondi, J.L.G. Fierro, M.C. Capel-Sánchez, *Materials Letters* **88**, 93 (2012).

[7] Carlos Angulo Barrios, *Analytical and Bioanalytical Chemistry* **403**, 1467 (2012).

[8] F.J. Ortega, M-J. Bañuls, F.J. Sanza, R. Casquel, M.F. Laguna, M. Holgado, D. López-Romero, C.A. Barrios, Á. Maquieira and R. Puchades, *Biosensors* **2**, 291 (2012).

[9] C.A. Barrios, S. Carrasco, M. Francesca, P. Yurrita, F. Navarro-Villoslada, and M.C. Moreno-Bondi, *Sensors and Actuators B* **161**, 607 (2012).

[10] C.A. Barrios, C. Zhenhe, F. Navarro-Villoslada, D. López-Romero, and M.C. Moreno-Bondi, *Biosensors and Bioelectronics* **26**, 2801 (2011).

[11] F.J. Sanza, M. Holgado, F.J. Ortega, R. Casquel, D. López-Romero, M.J. Bañuls, M.F. Laguna, C.A. Barrios, R. Puchades, and A. Maquieira, *Biosensors and Biolectronics* **26**, 4842 (2011).

[12] F.J. Sanza, M.F. Laguna, R. Casquel, M. Holgado, C.A. Barrios, F. Hortigüela, D. López-Romero, J.J. García-Ballesteros, M.J. Bañuls, A. Maquieira, R. Puchades, *Applied Surface Science* **257**, 5403 (2011).

[13] F.J. Aparicio, M. Holgado, I. Blaszczyk-Lezak, A. Borras, A. Griol, C.A. Barrios, R. Casquel, F. J. Sanza, H. Solhstrom, M. Antelius, A.R. González-Elipe and A. Barranco, *Advanced Materials* **23**, 761 (2011).

[14] C. F. Carlborg, K. B. Gylfason, A. Kaźmierczak, F. Dortou, M. J. Bañuls Polo, A. Maquieira Catala, G. M. Kresbach, H. Sohlström, T. Moh, L. Vivien, J. Popplewell, G. Ronan, C.A. Barrios, G. Stemme and W. van der Wijngaart, *Lab Chip* **10**, 281 (2010).

[15] Kristinn B. Gylfason, Carl Fredrik Carlborg, Andrzej Kazmierczak, Fabian Dortu, Hans Sohlström, Laurent Vivien, Carlos A. Barrios, Wouter van der Wijngaart and Göran Stemme, *Optics Express* **28**, 3226 (2010).

[16] M. Holgado, C.A. Barrios, F.J. Ortega, F.J. Sanza, R. Casquel, M.F. Laguna, M.J. Bañuls, D. López-Romero, R. Puchades, A. Maquieira, *Biosensors and Bioelectronics* **25**, 2553 (2010).

[17] María-José Bañuls, Victoria González-Pedro, Carlos A. Barrios, Rosa Puchades and Ángel Maquieira *Biosensors and Bioelectronics* **25**, 1460 (2010).

[18] D. López-Romero, C.A. Barrios, M. Holgado, M.F. Laguna, and R. Casquel, *Microelectronic Engineering* **87**, 663 (2010).

6.7 Integrated Optochemical Microsensors and Photoinduced Electron Transfer Using GaN [7]

Elías Muñoz

During the last years ISOM-UPM has been cooperating with GSOLFA-Org. Chem. Dept.-UCM* on the development of optochemical microsensors for gas sensing. Research was aimed to obtain direct grafting of long-lived luminescent indicator dyes on GaN LED chips, and to fabricate an integrated sensor electronic system to be plugged to a cellular smartphone for O_2 sensing. Besides, our unexpected results on photoinduced electron transfer (PET) from the Ru-dye to InGaN semiconductors appear attractive for developing novel photoelectrochemical dye-sensitized solar cells based on such materials.

Development of integrated devices for chemical monitoring is a priority goal of very different areas such as lab-on-a-chip systems, portable environmental monitoring, cell-phone-as-sensor devices and medical sensors, where the device size and fast response are paramount. For instance, smart cell phones and available sensor devices could create an opportunity to reach people who previously had no access to technology-based healthcare solutions [1]. Smartphones might incorporate specific microchemo-(bio)sensors for detecting the target analyte for each application. Among the different sensor types, *optical* chemical sensors display advantages such as the lack of analyte consumption, specificity, robustness and the possibility of contactless measurements. Basically, such systems require a proper light emitting diode (LED) as excitation source, an opto-chemical transducer, a photodetector element and suitable signal processing electronics [2]. Miniaturization of the latter plus the optical block is not a trivial issue. Luminescence lifetime-based sensors display the highest stability compared to intensity-based devices. Moreover, for sensing applications, a system based on the frequency domain rather than pulse-probe detection (namely luminescence phase shift determination by the demodulation technique) is usually the selected choice. In this case, the excited state lifetime of the luminescent dye is calculated from the phase shift between a sinusoidally modulated excitation and the modulated emission lightwave [3]. All these processes would be readily performed by current smartphones with the help of some signal conditioning and front signal processing electronics.

Ultra-miniaturization of the optical block by direct functionalization of GaN surface with adequate luminescent molecular probes was addressed. With this aim in mind, we selected O_2 sensing to demonstrate the feasibility of such a concept. The advantage behind such functionalization is to use the semiconductor not only as a substrate of the luminescent dye, but also as the excitation source, bringing an optical chemosensor down to the microscale.

Luminescent ruthenium(II) polyazaheterocyclic complexes pervade among the O_2 indicator dyes for environmental and industrial applications because of their wide absorption in the blue region, strong red emission, 0.2–7 μs luminescence lifetimes and extraordinary photostability. Although some reports on GaN functionalization have been published to date, to the best of our knowledge, no molecular dye has ever been chemically immobilized on the surface of this semiconductor. A novel functionalization method was developed that allows derivatization of LED chips without disturbance of the emission features of such devices for sensing applications. Samples about 7 x 7 mm of n-type GaN ($n > 10^{18}$ cm^{-3}) and of p-type GaN (nominal Mg ~$10^{19} cm^{-3}$), grown on sapphire substrates by MOVPE were used.

Standard 300 x 300 mm GaN/InGaN MQW blue LED chips (FOREPI, TW) with metallic contacts and with top surface layer being plain p-GaN, were also used in the experiments. As reference samples, glass squares (7 x 7 mm) were cut from a microscope slide and functionalized following the same procedure as that for the GaN samples.

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The method we have developed for grafting ruthenium(II) complexes to GaN surfaces requires three steps: (i) oxidation of the material outermost layer; (ii) aminosilanization of the hydroxylated surface, and (iii) covalent attachment of the polysulfonated ruthenium indicator dye. The oxidation step was initially performed by introducing the semiconductor into a H_2SO_4/H_2O_2 ("piranha") mixture for 30–60 min. Such a chemical oxidation turned out to be too aggressive for the metal-semiconductor contacts of a LED chip. Therefore, an efficient new method based on plasma treatment was developed for the semiconductor device functionalization. Such method has been tested on both n- and p-type GaN surfaces. It entails an oxygen plasma treatment applied for 10 min to generate hydroxyl groups on the GaN surface. After the plasma treatment, the silanization is carried out with 3-amino-propyltriethoxysilane (APTES). Final reaction with the sulfonyl chloride of the luminescent complex leads to the desired *covalent attachment* of the O_2 indicator dye via formation of a strong sulfonamide bond-APTES [4,5]. These steps and the final structure are schematized in Figure 6.7.1. Following chemical functionalization, wire bonding to the LED contact pads was performed to electrically drive the device.

GaN surfaces were characterized in detail by XPS after each of the steps for proper functionalization (Prof. C. Palacio, UAM). The evolution of the S 2p core-level XPS spectra allowed to differentiate between merely adsorbed and covalently bound Ru indicator dye on silanized GaN substrates. It was found that silanization of n-type GaN is more efficient than of p-type GaN surfaces (100% vs. 78% coverage for p-type)[4,5].

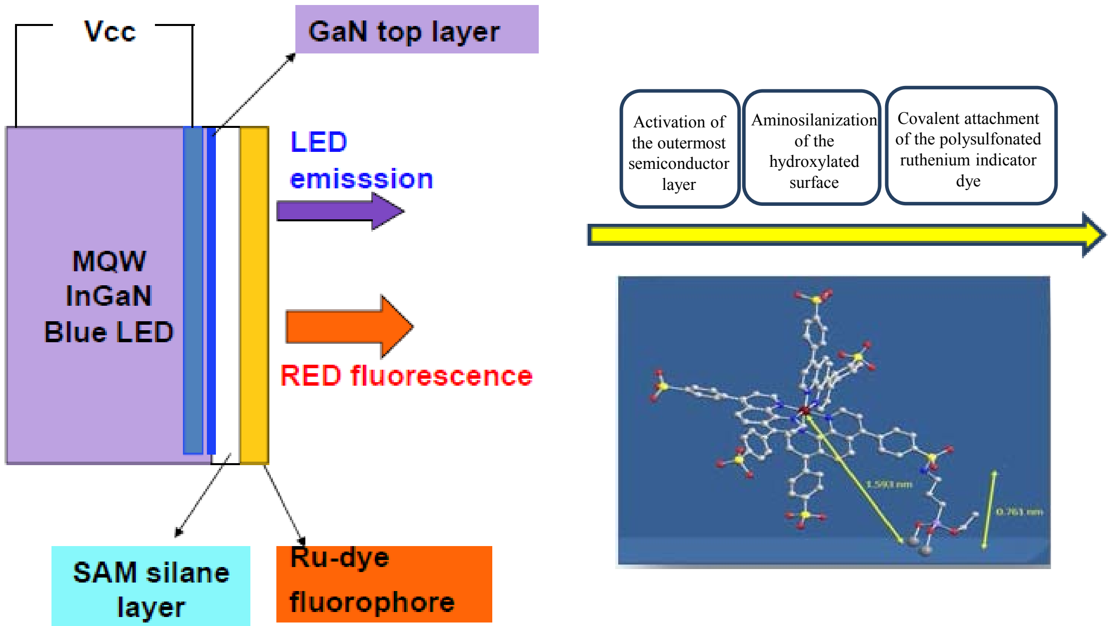

***Figure 6.7.1**.- a) Schematic diagram of the O_2 microsensor; b) the three steps followed to achieve the functionalization of n- and p-type GaN surfaces for covalent anchoring of the Ru dye; c) depiction to scale of the silane self-assembled monolayer (SAM) and of the anchored Ru dye.*

For luminescence decay measurements, a fluorescence lifetime imaging microscope (FLIM) was used to characterize the functionalized LED chips and GaN samples. A laser diode provides the external excitation source (463 nm peak wavelength, 900 ps pulse width, 100 to 10 KHz repetition rate). For lower noise operation, the system can be linked to a single photon timing (SPT) module equipped with a fast red-sensitive photomultiplier (PMT). Testing interrogation of the GaN LEDs requires that the trigger signal is fed to standard pulse generators and oscilloscope. One important point has been to find the LED driving conditions to minimize the parasitic residual LED red emission.

The SPT luminescence decays under (O_2-free) Ar atmosphere, from the photoexcited [Ru(pbbs)$_3$] bonded to n-type and p-type GaN samples and from reference glass, are shown in Figure 6.7.2. Such emission decays show significant differences in their kinetics. While p-GaN displays a mean lifetime of ca. 2 µs, the n-GaN sample displays a luminescence lifetime as low as 600 ns, pointing out the occurrence of a deactivation (quenching) process involving the ruthenium(II) dye [5].

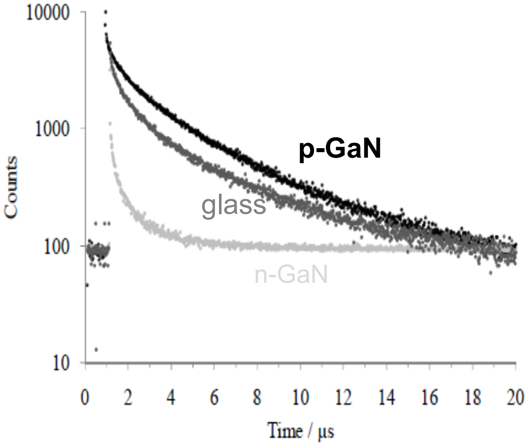

Figure 6.7.2. *Luminescence decays of Ru(pbbs)$_3$ grafted n-GaN (light grey), p-GaN (black) and glass (dark grey) under argon (λ_{exc} = 463 nm; λ_{em} > 590 nm).*

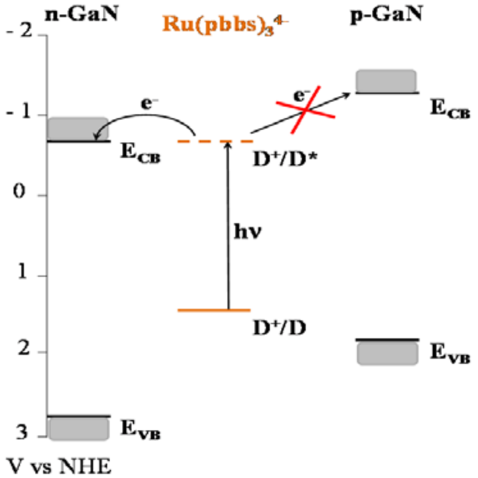

Figure 6.7.3. *Redox potentials of [Ru(pbbs)$_3$] vs. the GaN energy bands, and the electron-transfer process (PET) from the photoexcited complex to the n-type semiconductor.*

To understand the above results, figure 6.7.3 depicts a scheme of the proposed photoinduced electron transfer (PET) process from the grafted dye to the n-GaN semiconductor, quenching the fluorophore luminescence. The band-edge potentials of n-GaN and p-GaN (in V vs. NHE, Normal Hydrogen Electrode) in water at pH 7, have been published [6]. The excited state oxidation potential (D^+/D^*) of the original ruthenium dye in acetonitrile (–0.60 V vs. NHE) can be calculated from the difference between the oxidation potential of the ground state metal complex (D^+/D = 1.41 V vs. NHE) and the HOMO-LUMO energy gap (2.01 eV) obtained from the dye emission maximum (618 nm). Figure 6.7.3 also illustrates that a PET injection from the excited dye to the p-GaN semiconductor is not feasible. To the best of our knowledge, this is the first time that a PET process from a dye to a nitride semiconductor is reported. One may now remind that in dye-sensitized solar cells (DSSCs), the key process is the injection of the photogenerated electrons in the Ru-dye to the semiconductor (usually nanoparticles of TiO_2 or SnO_2). In this case, the goal in DSSC devices is to maximize the PET process from the dye to the semiconductor material. The functionalization of GaN achieved in our work leads to a structure where dye and semiconductor are covalently bonded in close vicinity, situation that may increase substantially the efficiency of the electron injection as compared to a dye just absorbed by the semiconductor.

The dye deactivation efficiency is actually so large that the functionalized n-GaN surfaces are not sensitive to the presence of molecular oxygen. A negligible variation of the emission decay lifetime is observed when the semiconductor environment changes from 0% to 100% O_2. Therefore, the ruthenium-functionalized n-GaN material cannot be used for our chemical sensing applications. However, in the case of p-GaN (fig. 6.7.4), the luminescence decay accelerates and the emission lifetime notably decreases in the presence of O_2.

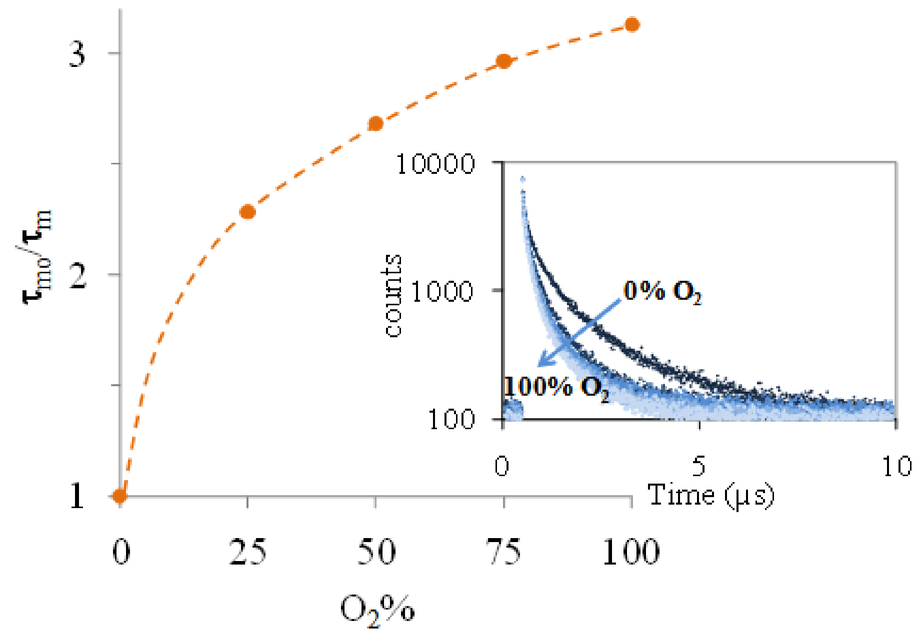

Figure 6.7.4. *Stern-Volmer plot obtained from the decay lifetime values. Inset: Evolution of the luminescence decays of ruthenium dye-grafted p-GaN with the oxygen concentration in argon (λ_{exc} = 463 nm; λ_{em} > 590 nm).*

The novel GaN functionalization processes have been applied to sensorization of blue LED chips. Figure 5 depicts the bright-field and fluorescence micrographs of a dye-grafted LED chip. The former image (fig. 6.7.5.a) gives an idea of the device size. A strong blue emission can be seen when a proper voltage is applied to the LED (fig. 6.7.5.b). Using a dichroic mirror at 490 nm and a cutoff filter at 590 nm, the red emission of the functionalized LED is also observed under the same operating conditions (fig. 6.7.5.c). Nevertheless, it is known that GaN-based LEDs display a residual emission in the red region that peaks at ca. 670 nm. To confirm that the observed red emission of the functionalized LED originates from the covalently attached ruthenium complex and not from the GaN itself, the luminescence decays of an operating LED before and after the dye grafting were recorded (fig. 6.7.5.d). The original device (black dots) displays only a very fast emission decay, which can be attributed to the residual red emission of the GaN, while the functionalized device (orange dots) shows also a distinct long-lived red emission characteristic of the ruthenium complex emission. Therefore, it can be concluded that the emission depicted in figure 6.7.5.c proceeds mainly from the tethered luminescent dye [5].

To further test the proposed PET process from the dye to n-type GaN, new silanization experiments using silanes of a longer molecule than APTES were performed. As expected, luminescent intensities from the Ru-dye now decrease and the emission lifetime increases markedly as the thickness of the silane (mono)layer is expected to increase in thickness (e.g. ~10Å for APTES to ~20 Å for DAHTMS)[6].

Because of the relevance of PET processes for DSSC and fluorescence applications, a study was made for a number of wide band gap semiconductors by taking, on one hand, their electron affinity and band-gap and, on the other hand, the oxidation potential of excited (D^+/D^*) and ground state (D^+/D) Ru dye in V vs. NHE. The NHE potential vs. vacuum was taken as 4.5 eV. Figure 6.7.6 summarizes such calculations, suggesting that InGaN alloys provide a unique tunability for PET processes not offered by the semiconductor binaries usually used (TiO_2, SO_2, ZnO), and that may lead to improved DSSC [7].

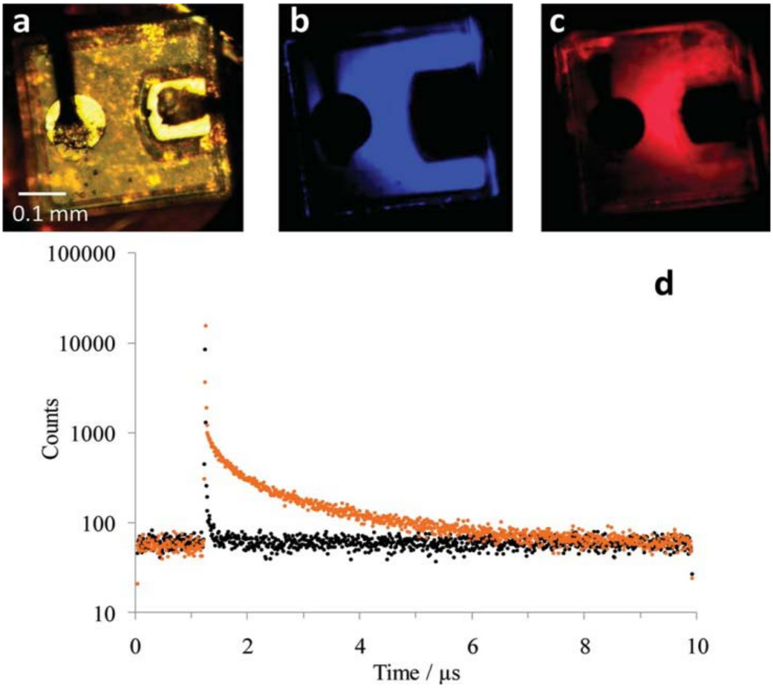

Figure 6.7.5. *Microscopy images of a ruthenium dye-grafted LED: (a) bright field; (b) blue emission, (λ_{em} > 440 nm); (c) red emission (λ_{em} >590 nm). (d) Luminescence decays of a non-functionalized (black dots) and covalently functionalized LED (orange dots) in operation (λ_{em} > 590 nm).*

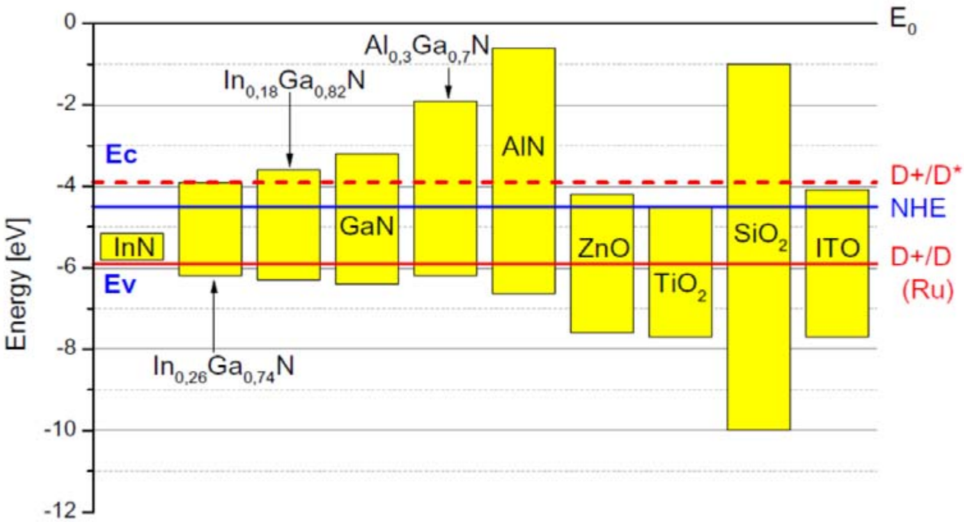

Figure 6.7.6. *From the electron affinity data for a selected wide band-gap semiconductors, this chart shows their conduction and valence band energy positions vs. vacuum, and vs. the oxidation potential of excited (D^+/D^*) and ground state (D^+/D) Ru indicator dye. The NHE potential vs. vacuum was taken as 4.5eV.*

In advanced InGaN LED technology, to lower ohmic contact resistances in the top p-type layer, a thin p-type InGaN film (typically 10% In) is grown on the p-GaN surface, and afterwards the metal ohmic contacts are deposited. Samples from LED wafers using such technology (AOT, TW) were functionalized using the processes described above. It was shown that the red emission from the Ru dye was also quenched, suggesting that a PET process is now present, as it was shown for n-type GaN, and in accordance with the trends depicted in figure 6 for InGaN.

Finally, the front electronics for the O_2 microsensor is being developed using a DSC (digital signal controller) from Microchip Co. that combines a microcontroller and a DSP Core. The optochemical block uses standard PIN photodetector and transimpedance amplifier. The information about the O_2 content is calculated from the phase shift of the red emission from the Ru indicator dye, and will be initially transmitted to the smartphone by *bluetooth*.

Integrable microsensors based on luminescent indicators grafted to GaN are of interest to realize the cell-phone-as-sensor concept for in situ gas analysis. For such goal, specific microchemo-(bio)sensors for detecting the target analyte have to be developed in each application, and the ultraminiaturization of the optical block and signal conditioning electronics have to be also achieved. Thus, the direct functionalization of a GaN excitation source with engineered Ru-based luminescent molecular probes was addressed, and O_2 sensing was selected to prove such a concept. It was found that a p-GaN surface rather than n-GaN is required for fabrication of the sensitive device to avoid a PET process that deactivates the indicator dye emission. The functionalized InGaN MQW emitter leads to a higher sensitivity of the resulting structure to the analyte sensing. The sensor signal conditioning front electronics, based on compact DSC and using a phase shift technique, is being tested. Further studies to tether GaN to tailored red-luminescent indicator dyes are currently being explored for carbon monoxide, ethyl alcohol and hydrogen sulfide gas sensing.

References

[1] Ryhänen, T., Uusitalo, M. A., Ikkala, O. and Kärkkäinen, A., Eds., *“Nanotechnologies for Future Mobile Devices”,* Cambridge University Press, Cambridge (2010).

[2] Orellana, G. and García-Fresnadillo, D., in *“Optical Sensors: Industrial, Environmental and Diagnostic Applications”*, Springer, Berlin-Heidelberg, 309-357 (2004).

[3] Navarro, A., PhD Thesis, ETSIT-UPM, Dept. Electronics Eng.-ISOM (2011).

[4] López-Gejo, J., Arranz, A., Navarro, A., Palacio, C., Muñoz, E. and Orellana, G., *J. Am. Chem. Soc*. **132**, 1746 (2010).

[5] López-Gejo, J., Arranz, A., Navarro, A., Palacio, C., Muñoz, E. and Orellana, G*., Am. Chem. Soc. Appl. Mater. Interf.* **3**, 3846 (2011).

[6] Bard, A. J., "*Electrochemical Methods: Fundamentals and Applications",* Wiley, New York (2001).

[7] Orellana, G., Muñoz, E; Gil-Herrera, L K; Munoz, P; López-Gejo, J; Palacio, C., *"Integrated luminescent chemical microsensors based on GaN LEDs for security applications using smartphones"*, Proc. SPIE Optical Materials and Biomaterials in Security and Defence Systems Technology IX, 8545, 85450J (2012).

6.8 Graphene devices for flexible, optoelectronic and energy applications [8]

Jorge Pedrós, Javier Martínez and Fernando Calle

Graphene has attracted increasing attention in recent years due to its excellent mechanical, optical and electrical properties [1]. Its high electrical conductivity and surface area make it an attractive material for many industrial applications [2]. The graphene two-dimensional (2D) sheets allow to make new electronic and optoelectronic devices, while three-dimensional (3D) graphene structures are also useful for energy storage. Due to this promising future the ISOM created in 2011 a new research group (www.isomgraphene.es) to study the technology and applications of graphene. This group collaborates with many institutions of international relevance and some industrial companies. The research includes growth [3-5], transfer [6,7], and processing [8,9] of graphene, even on flexible substrates [10,11] as well as its structural, optical and electrical characterization [12-15], and applications in the energy [16-18] and optoelectronics [19] fields.

I. Graphene growth

A layer of graphene can be prepared by several techniques: mechanical exfoliation from graphite, sublimation of silicon on a silicon carbide surface, reduction of exfoliated graphene oxide, carbonization from polymers, and chemical vapor deposition (CVD). In this report PMMA is used as a carbon source for creating extremely thin graphene-like layers [3]. By reactive ion etching (RIE), the height of the PMMA coating is reduced to a few nanometers. Heating up this thin layer in an oven to 1200ºC, the oxygen atoms are removed from the polymer. Quality is improved by using Ni as a catalyst. Figure 6.8.1 shows an AFM image of a graphene layer and the Raman spectra at different growth conditions.

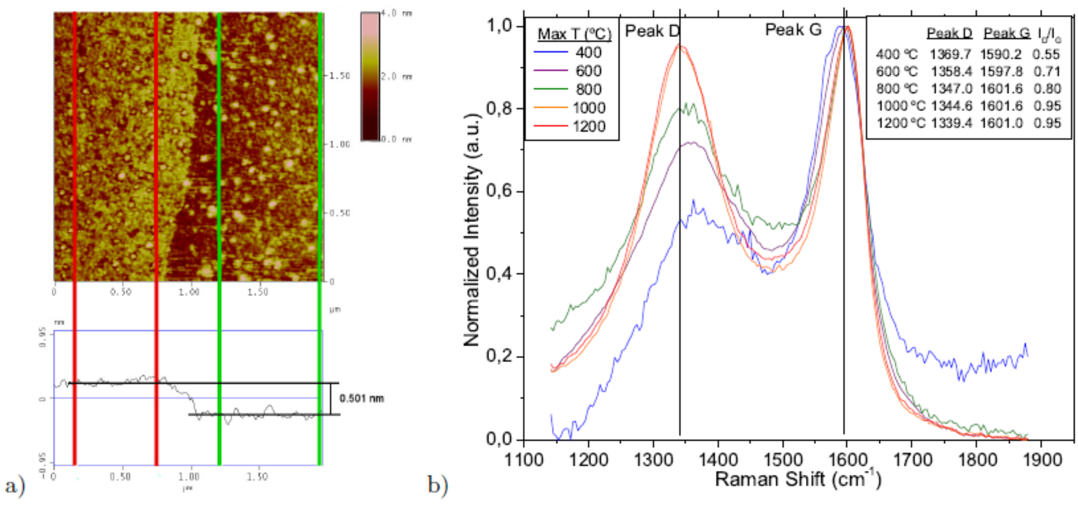

***Figure 6.8.1**. a) AFM image of a graphene layer. b) Raman spectra for different temperatures.*

For electronics applications the most used technique is CVD. Figure 6.8. 2.a shows an image of the plasma enhanced CVD (PECVD) equipment recently installed at ISOM. The synthesized graphene is commonly grown on a flat metal foil or thin film. This method provides high quality graphene, and can also be used to fabricate 3D graphene structures using metallic foams [4,5]. Figure 6.8.2.b shows a scanning electron microscopy (SEM) picture of a graphene foam, which has a very high conductivity and surface area.

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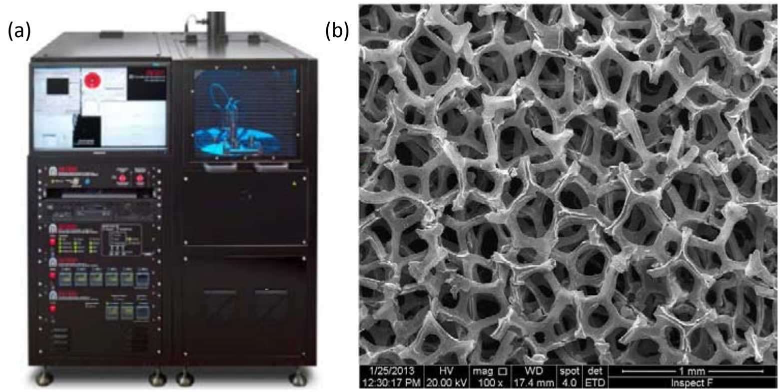

Figure 6.8.2. *a) PECVD equipment at ISOM, b) SEM picture of the graphene 3D foam*

II. Graphene transfer

The main drawback of the CVD method is the resist residues left during the transference process, affecting strongly to the material properties. These residues can affect the carrier mobility or the contact resistance of the final device. To solve this problem a new method to transfer the grapheme, or other 2D layered materials, to an arbitrary substrate [6,7] has been developed that keeps the scalability of CVD graphene with a large surface coverage.

III. Graphene characterization

Once grown, the graphene structures need to be characterized. Structural characterization was performed by scanning electron microscopy (SEM) [4,5] and atomic force microscopy (AFM) [12]. A more detailed characterization of the quality of the graphene has been done by Raman spectroscopy. Finally, an electrical characterization was carried out to determine the electronic properties of the material [14-15].

Several applications of graphene rely on the integration of 2D graphene sheets into 3D structures while keeping their unique properties, such as the high surface area and electrical conductivity. A novel approach to fabricate graphene/metal oxide composites uses 3D Ni foams as templates where the graphene is grown by CVD. After removing the metal scaffold, the free-standing graphene foams can be characterized. These graphene 3D networks are being investigated, for example, as advanced materials for sensors and electrodes in energy storage devices, such as supercapacitors and lithium ion batteries. The properties of graphene grown by CVD and PECVD on 3D Ni and Cu foams using CH_4 or C_2H_2 as precursors are reported. The temperature, pressure, and plasma conditions were varied to study their effect on the graphene properties. The graphene/metal foam structures have been characterized by Raman spectroscopy and scanning electron microscopy (SEM). The structural characteristics and the homogeneity of the graphene coating are discussed in terms of the growth conditions.

It is demonstrated that an accurate control of the number of graphene layers is achieved by tuning the deposition conditions, not only by CVD at standard temperatures (T~1000ºC) but also by PECVD at reduced temperatures as low as 700ºC. Figure 6.8.3 presents the Raman spectra (left) and SEM images (right) of graphene layers grown by PECVD on Ni foams at 600ºC, 700ºC, and 800ºC. The quality and number of layers evolves with temperature as follows. At T = 600ºC, the D and D' Raman peaks indicate the presence of defects in the graphene coating, that are associated to the formation of nanocrystals, as confirmed by the textured morphology observed by the SEM image (top, right). At T = 800ºC, the 2D Raman peak (bottom, left) presents a graphite-like shape, indicating a large number of layers. However, at T = 700ºC the Raman spectrum in figure 6.8.3 (center, left) indicates that defect-free bilayer (or few-layer) graphene is obtained.

SEM images indicate an almost continuous coverage of the foam surface (fig. 6.8.3, center, right), with some influence from its grain structure. The optimum temperature of the PECVD process presented is much lower than that previously reported for CVD graphene foams.

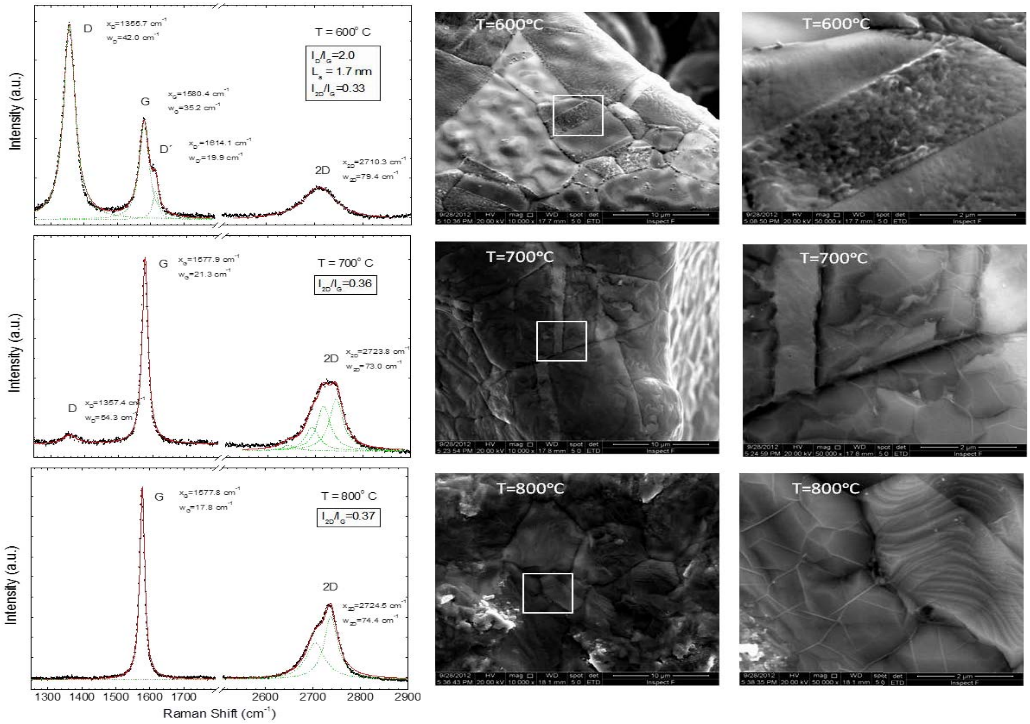

Figure 6.8.3. *Characterization of graphene foams grown by CVD at different temperatures.*

Finally, a physical model for electrical measurements in graphene has been developed (fig. 6.8.4). From a field effect transistor made of graphene (GFET), it is possible to get useful information from different parameters such us doping, carrier mobility, serial resistance, carrier concentration, etc. Using these values in the proposed model, a better understanding of different parameters can be obtained, such as: the Dirac Point shift with fixed charge, current modulation with V_G, temperature dependence, etc.

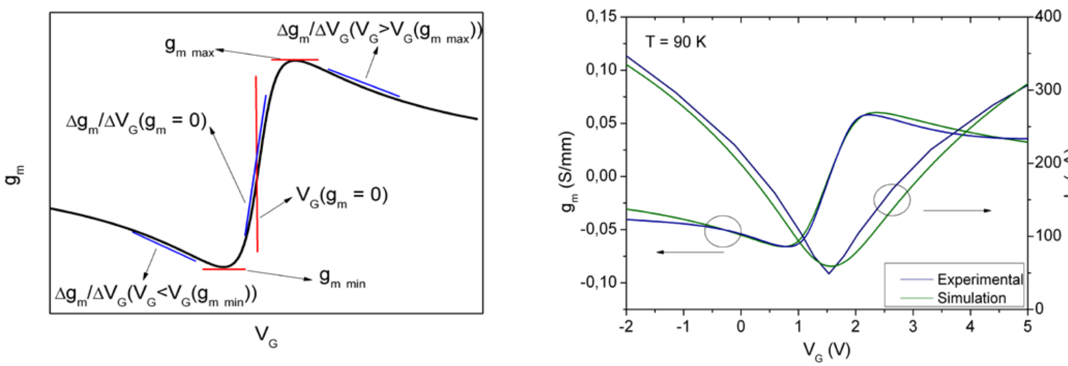

Figure 6.8.4. *a) Scheme of the parameters used in the fitting of electrical properties of the GFET, and b) comparison of the simulation and experimental results for the transconductance and current curves.*

IV. Graphene flexible devices

Graphene is a flexible transparent material that can be used for sensors, solar cells, light emitting diodes (LEDs), organic LEDS (OLEDs), touchscreens and liquid crystal displays (LCD). In the near future its flexibility will lead to creating foldable and wearable devices.

The high conductivity, large area and porosity of 3D graphene structures make them an ideal material for flexible electronics. In order to create these structures, graphene oxide (GO) is used, together with a laser to reduce this material and change its conductivity. Figure 6.8.5.a shows an SEM image of the graphene pattern. The graphene structures were coated partially with PMMA for mechanical stability and sealed inside a plastic container with an electrolyte and two electrical contacts. This flexible device can store energy when it is polarized by a positive bias, and can light up several commercial LEDs as it is shown in figure 6.8.5.b [11].

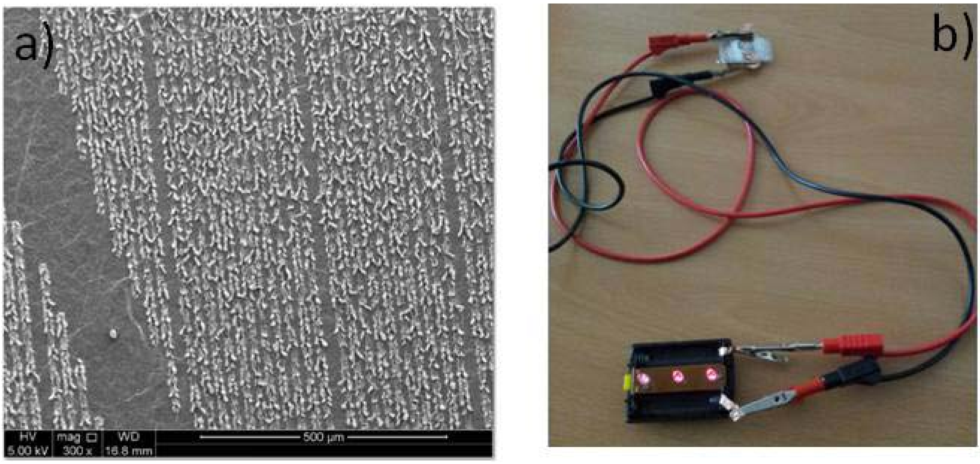

Figure 6.8.5. *a) SEM image of a GO layer after laser treatment. b) Flexible device lighting 3 LED*

V. Energy storage with graphene devices

Commercial Ni foam was used as a catalytic metallic mesh to grow graphene by PECVD. Analyzing the sample by Raman spectroscopy, one can observe that the graphene has a thickness of just a few atomic layers. In a posterior step, the Ni template was removed immersing the sample in HCl acid during several hours. The graphene foam obtained was characterized by scanning electron microscopy (SEM) showing similar morphology than the original foam. This graphene foam has been used as the electrode material in a supercapacitor device [16-18].

A home-made supercapacitor cell was built in polypropylene with two stainless steel collectors (fig. 6.8.6.a). Two 3D graphene foam discs were inserted inside the cell with a porous separator between them. This sandwich structure was dipped in a 1 mol L^{-1} KOH aqueous solution that acts as the electrolyte. The two collectors of the supercapacitor cell were connected to a potentiostat/galvanostat equipment. The electrochemical measurements are plotted in figure 6.8.6.b. In this graph one can observe the charge and discharge of the 3D graphene supercapacitor. The specific capacitance of these devices may surpass 100 Fg^{-1}, and further capacitance values can be reached by using several additives, like metal oxide nanoparticles or carbon nanotubes.

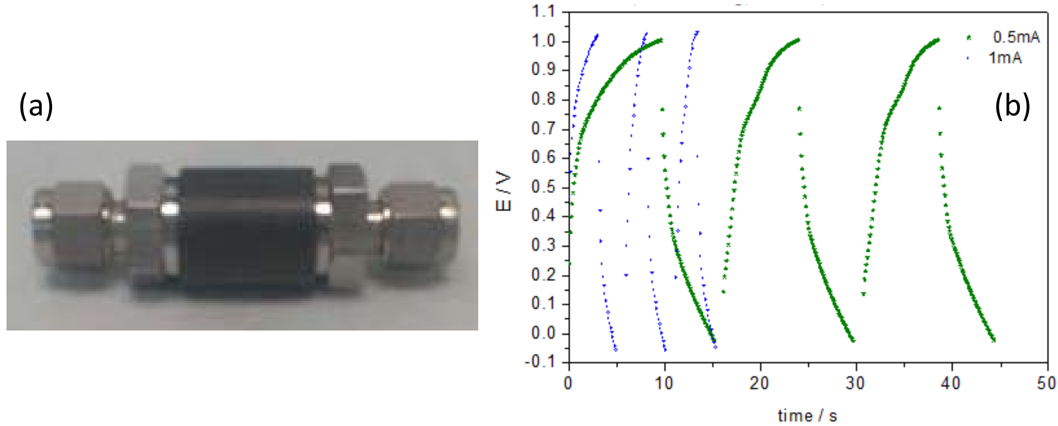

Figure 6.8.6. *a) Picture of the graphene supercapacitor cell. b) Charge/discharge cycles in the graphene supercapacitor cell at 0.5 mA and 1 mA.*

VI. Graphene for optoelectronics

It is demonstrated that surface acoustic waves (SAWs) can be used to generate a switchable refraction grid which couples laser light into the hybridized plasmon supported by graphene on piezoelectric materials like, for example, ZnO and AlN (fig. 6.8.7). The coupling to surface phonons shifts the low wave vector part of the graphene plasmon dispersion, which is virtually unaffected by intra-band losses, upwards into the attractive mid-infrared frequency range [19]. Because of their relatively low damping in the vicinity of the surface-phonon frequency, these phonon-like plasmon branches have a high potential for photonic applications. The proposed scheme for plasmon excitation using far-field radiation avoids the patterning of graphene, diminishing the edge scattering and generating propagating plasmons which could be used in future graphene-based plasmonic devices. Moreover, plasmons can be switched electrically, via the high frequency signal at the IDT, whereas the plasmon resonance can be tuned via electrostatic gating. In addition, the IDT technology allows for many different plasmon functionalities.

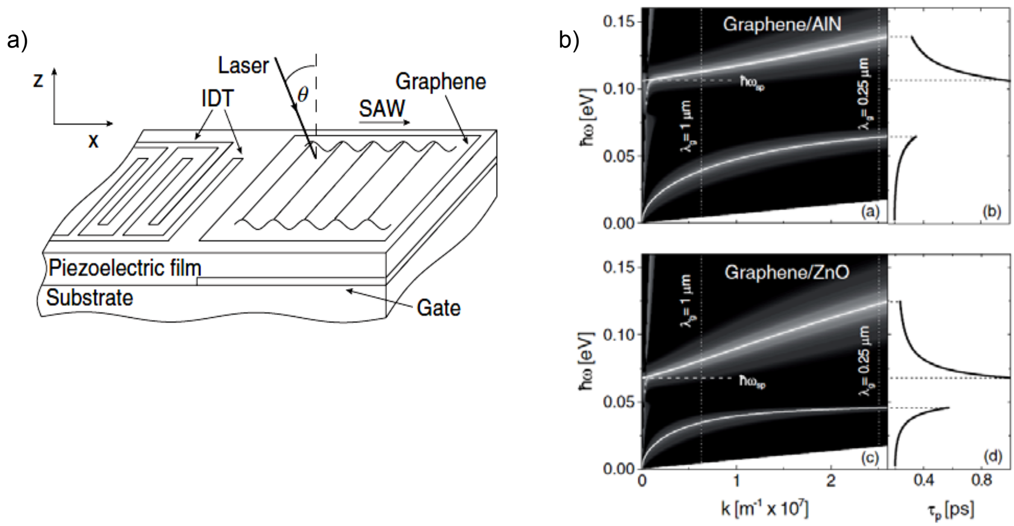

Figure 6.8.7. *a) Scheme of the device. b) Plasmon dispersion for graphene on AlN and on ZnO.*

References

[1] A.K. Geim, K.S. Novoselov, *Nature Materials* **6**, 183 (2007).

[2] F. Calle, A. Boscá, J. Pedrós, M.J. Tadjer, J. Martínez, ULab - Nanotech Italy 2012. Venezia, November 21-23 (2012).

[3] A. Boscá, D. López-Romero, S. Alvarez. A. de Andrés, J. Martínez, F. Calle, *Graphene-like layers obtained from PMMA.* 21th European Workshop on Heterostructures Technology, Barcelona, November 5-7 (2012).

[4] J. Pedrós, K.B. Teo, J. Martínez, S. Álvarez, A. Boscá, A. de Andrés, F. Calle. *CVD of graphene on 3-dimensional metal foams for energy-storage applications.* Graphene 2013, Bilbao, April 23-26 (2013).

[5] J. Pedrós et al., *Effect of grain orientation on the growth of 3-dimensional graphene networks on polycrystalline Ni foams by chemical vapor deposition*, to be published.

[6] A. Boscá, J. Pedrós, J. Martínez, F. Calle, T. Palacios, *Procedimiento de transferencia de nanocapas y aparato de realización del mismo*. OEPM, P 6400/2013.

[7] A. Boscá, J. Pedrós, J. Martínez, F. Calle, T. Palacios, *Automatic graphene transfer*, to be published

[8] F. Calle, D. López-Romero, A. Boscá, M.J. Tadjer, T. Palacios. *Technology for graphene-based nanoelectronic devices.* Sectorial Meeting Graphene for ICT, Castelldefels, September 23 (2011).

[9] A. Boscá, D. López-Romero, J. Martínez, J.A. Garrido, T. Palacios, F. Calle, *Ambient p-doping of CVD graphene.* Proc. Graphene 2012. Brussels, Belgium, April 10-13 (2012).

[10] J. Martínez, A. Boscá, A. Bengoenchea-Encabo, S. Albert, M. A. Sanchez-Garcia, E. Calleja, F. Calle. *Graphene electrodes for nano-LEDs.* Graphene 2012. Brussels, Belgium, April 10-13 (2012).

[11] J. Martínez, D.J. Choi, S. Shrestha, T. Valero, A. Boscá, J. Pedrós, F. Calle. *Flexible graphene device for lighting LEDs.* Graphene 2013, Bilbao, April 23-26 (2013).

[12] C. Munuera, M. García, A. Bengoechea, S. Albert, M. A. Sanchez-García, E. Calleja, F. Calle, J. Martínez, *AFM electrical characterization of graphene nano LEDs.* Scanning Probe Microscopies 2013. Bilbao, April 23-26 (2013).

[13] M.J. Tadjer, T.J. Anderson, K.D. Hobart, L.O. Nyakiti, V.D. Wheeler, R.L. Myers-Ward, D.K. Gaskill, C.R. Eddy, Jr., F.J. Kub, F. Calle. *Appl. Phys. Lett*. **100**, 193506 (2012).

[14] A. Boscá, F. Calle, T. Palacios. *Physical model for electrical measurements in graphene.* 21th European Workshop on Heterostructures Technology, Barcelona, November 5-7 (2012).

[15] A. Boscá et al., *Extracting relevant parameters from graphene devices electrical characteristics using a transport model*, to be published.

[16] F. Calle, A. Boscá, J. Pedrós, J. Martínez. *Energy Storage based in Graphene.* Graphene Closing Meeting. Tres Cantos, Madrid, April 2-4 (2013).

[17] J. Martinez, A. Boscá, J. Pedrós, D. J. Choi, S. Shrestha, V. Barranco, J.M. Rojo, F. Calle. *3D graphene supercapacitor for energy applications.* Trends in NanoApplications Energy, TNA 2013. Bilbao, April 23-26 (2013).

[18] J. Pedrós, A. Boscá, D.J. Choi, S. Shresta, J. Martínez, F. Calle. *Energy storage systems based on graphene.*. UPM Summer Course on "Emerging Applications of Graphene". Madrid, July 15-16, 2013.

[19] J. Schiefele, J. Pedrós, F. Sols, F. Calle, F. Guinea. *Phys. Rev Lett.* **111**, 237405 (2013).

6.9 MEMS Devices compatible with CMOS technology [9]

Gonzalo Fuentes and Fernando Calle

Within this research area, low temperature manufacturing recipes have been developed for the integration of MEMS devices, such as surface acoustic wave (SAW) devices and microcantilevers, on CMOS technology. Low temperature processing means not just compatibility with CMOS standard procedures, it also translates into higher throughput and, as a consequence, lower manufacturing costs. The use of the piezoelectric properties of AlN manufactured by reactive sputtering at room temperature (RT) is an important step towards the integration of this type of devices with CMOS technology.

I. Surface acoustic waves (SAW)

The fast growth of communication media, such as mobile and satellite services, has induced a growing demand of high-performance (low loss) SAW devices, widely used as band-pass filters and resonators. These electronic devices employ SAWs to use one or more interdigital transducers (IDTs) to convert acoustic waves to electrical signals and vice versa by means of the piezoelectric effect [1]. SAW devices have been in commercial use for more than 60 years. The telecommunications industry is the largest consumer, accounting for ~3 billion acoustic wave filters annually, primarily in mobile cell phones and base stations. Several of the emerging applications for acoustic wave devices such as sensors may eventually equal the demand of the telecommunications market. These include automotive applications (torque and tire pressure sensors), medical applications (chemical sensors), and industrial and commercial applications (vapor, humidity, temperature, and mass sensors). Acoustic wave sensors are competitively priced, inherently rugged, very sensitive, and intrinsically reliable. Some are also capable of being passively and wirelessly interrogated (no sensor power source required) [2].

Thin film SAWs are the best candidates to replace the devices used nowadays, which present important disadvantages such as high cost and very difficult integration into CMOS technology because of its high manufacturing temperature. Even though AlN is used in many other microelectronic applications such as passivation layers, dielectric films, insulating layers, solar cell coatings, and short wave-length emitters, it is known to be one of the most promising piezoelectric materials for MEMS and high frequency SAW devices [3-6]. This is mainly due to the combination of its good piezoelectric properties and other advantages which favor it among other piezoelectric materials. In particular, its high ultrasonic velocity and good thermal and chemical stability are nowadays the most frequently used in many surface and bulk acoustic wave devices (SAW, BAW), like for example those used in miniature high frequency bypass filters for wireless communication or in various kind of sensors based on Lamb-wave propagation over AlN/silicon membranes [3,4]. Furthermore, its fabrication by sputtering [5] and the feasibility of electronic lithography for the transducers [6] make this material an excellent choice for a wide range of industrial applications.

Recently, the use of diamond as a substrate for high frequency and high temperature applications was reported by the group at ISOM. AlN is the ideal piezoelectric layer for diamond-based SAW devices, due to the good thermal stability, the excellent mechanical and chemical properties, but most of all due to the high acoustic wave velocity present in the heterostructure [7, 8].

In order to study the influence of the piezoelectric film thickness on the SAW response, one-port SAW resonators with a period of 800 nm were manufactured using 150 nm, 300 nm, 600 nm, and 1200 nm-thick AlN films on diamond ($kH=2\pi H/\lambda$= 1.18, 2.36, 4.71, and 9.42, respectively) [9]. The quality of the AlN film and hence its piezoelectricity are both thickness dependent. The compromise between selecting the right thickness while maintaining the crystal quality of the piezoelectric film is evident with the experimental data presented in this work. Thus, for an optimal design structure (IDT/piezoelectric film/diamond substrate), the first task is to calculate the dispersion characteristics of the layered system. Electrical characterization has

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been supported by an Agilent PNA N5230A Network Analyzer, which allows to characterize SAW devices in a wide frequency spectrum (from 300 kHz up to 20 GHz). The S-parameters of our devices were measured and, by characterizing different types of devices, the COM (Coupling Of Modes) parameters corresponding to each specific heterostructure (IDT/AlN/Diamond) was extracted [9].

The kH factor allowing a mode with the best combination of velocity and K_2 is selected. This choice implies a trade-off between the frequency and the intensity of the targeted resonances, i.e., a larger frequency can be achieved at the cost of larger losses. Once kH is chosen, and since $f= v/\lambda$, the smallest λ that can reliably be patterned is selected. This requires also a film thickness large enough to assure a good crystallographic quality. Since this is a limiting factor, a compromise should be made again between achievable frequency and intensity (insertion loss) of the targeted resonances.

Figure 6.9.1 shows the comparison between the reflection amplitude of these devices. Depending on the AlN thickness, different dips appear. For the SAW device on 150, 300 and 600 nm thick AlN, the dominant resonance appears at 14.03, 12.59 and 10.94 GHz respectively, and is associated with the first order Sezawa mode (labelled as S_1). However, for the 1200 nm thick structure this frequency is 11.53 GHz, and corresponds to the second order Sezawa mode (labelled as S_2). Other higher modes can be observed in each structure for the less intense resonances. The frequencies obtained are among the highest obtained for a SAW resonator so far. Finally, SAW resonators have also been used as high pressure sensors [10].

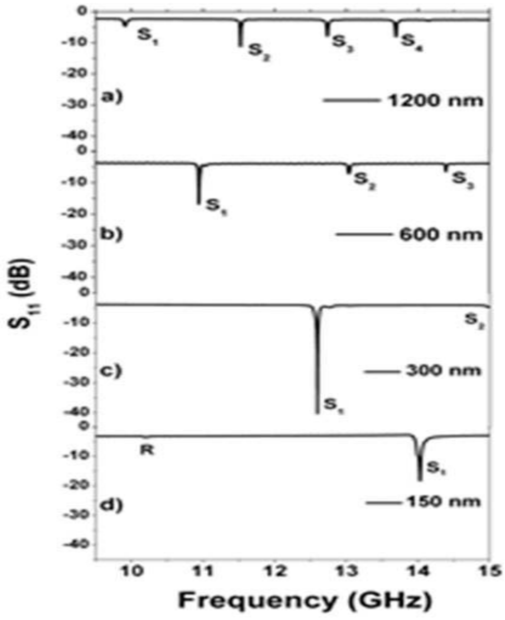

Figure 6.9.1. *Reflection coefficient S_{11} spectra for λ=800 nm one-port SAW resonators on (a) 1200 nm, (b) 600 nm, (c) 300 nm, and (d) 150 nm-thick AlN films on diamond. R and Si stand for Rayleigh and Sezawa modes.*

Figure 6.9.2. *Schematic of an AlN driven microcantilever, showing the AlN layer between the two electrodes deposited on a Si wafer.*

II. Microcantilevers

A cantilever is a beam structure anchored at only one end. In this work, high quality and reliable AlN-driven cantilevers for MEMS applications have been developed. Each cantilever consists of a thin film of AlN sandwiched between two metal (chromium) electrodes and deposited on top of a silicon wafer (fig.

6.9.2). Arrays of free-standing cantilever beams with several dimensions were manufactured to study their performance as sensors and actuators.

MEMS systems find nowadays a wide range of applications in many fields of science and industry. Dynamically developing microsystem markets make crucial to also develop new materials meeting the needs of this new technology. Cantilevers are used in a wide variety of applications such as sensors, detectors or energy harvesters. Zinc oxide (ZnO) and lead zirconium titanate (PZT) are commonly piezoelectric materials used for these applications, but they pose a contamination risk in tools shared with CMOS fabrication and can be difficult to process (e.g. low resistivity, composition control, cracking). In contrast, AlN is CMOS compatible because it can be grown at RT by reactive sputtering [5]. While the d_{33} piezoelectric response of AlN is less than that of ZnO or PZT, its other material properties (e.g. high elastic modulus and thermal conductivity, low density) make it superior [11]. Furthermore, microcantilevers have been employed for physical, chemical and biological sensing, and medicine, specifically for the screening of diseases, detection of point mutations, blood glucose monitoring and detection of chemical and biological warfare agents [12].

However, till now for actuation purposes in MEMS, PZT sol-gel films have been most commonly used, because of their high piezoelectric coefficients (around nine times greater than those of AlN) and the possibility to synthesize thicker films. Nevertheless, even though AlN does not exhibit the best piezoelectric properties, it still represents a very interesting alternative to be used in microactuators mainly because of its very good compatibility with standard silicon (CMOS) technology and possibility to be synthesized at low temperature (<400°C). Therefore, AlN offers the best compromise between performance and manufacturing of piezoelectrically actuated MEMS. Because of scale reduction, using different materials and different fabrication methods, the piezoelectric and mechanical properties of AlN and functionality based microstructures are strongly technology dependent [13]. AlN uniform piezo-devices offer an essential advantage over Pb- and Zn-containing solutions, being well suited for the integration in implants as sensors as well as power supplies to monitor human body parameters, e.g. the intraocular or arterial pressure. Recent works show promising properties of sputtered AlN thin films for energy harvesting [14].

One of the aims of this work is to design and study the performance of MEMS devices such as SAWs and microcantilevers based on AlN and manufactured at RT. To start with, the COMSOL Multiphysics engineering simulation software environment was employed to determine the eigenmodes of a piezoelectrically actuated polycrystalline AlN micro-cantilever. Further, the piezoelectric properties of aluminum nitride based MEMS devices were studied, as well as different manufacturing approaches, enabling the integration of these components on CMOS technology. The design and modeling of the microscale electro-mechanical systems (MEMS) is a unique engineering discipline. At small length scales, the design of resonators, gyroscopes, accelerometers, and actuators must consider the effects of several physical phenomena. MEMS devices and sensors may even utilize multiphysics phenomena for its very function or for increased sensitivity. To this end, the COMSOL MEMS Module provides user interfaces for electromagnetic-structure, thermal-structure, or fluid-structure interactions. For elastic vibrations and waves, perfectly matched layers (PMLs) provide state-of-the-art absorption of outgoing elastic energy.

The first microstructure developed has been an AlN/diamond heterostructure for high frequency (GHz) SAW applications [7]. The second one has been an array of piezoelectrically driven microcantilevers, which are widely used components in MEMS applications. In order to cope with the wide range of applications, the microcantilevers had different sizes and shapes, but they were all based on an AlN layer sandwiched between a pair of electrodes. Part of the work has focused on the growth of AlN layers on different substrates by reactive sputtering and its structural characterization (AFM, TEM and XRD). In addition, demonstrators were manufactured, such as high performance resonators (MEMS, FBAR and SAW) working in the GHz range frequencies, by far not reached for this type of devices. The group at ISOM has successfully fabricated AlN microcantilevers at RT by this method. The best way to ensure that the microcantilever is completely free is by scanning electron microscopy (SEM). Figure 6.9.3 is an SEM picture of the fabricated microcantilever with dimension of 50 μm width and length of 200 μm. It shows the fabricated microstructures of the Cr/AlN/Cr stack on Si substrate and the freestanding cantilever beams.

The microcantilever vibration has been characterized by measuring the out-of-plane displacement of surfaces by Laser Doppler Vibrometry (LDV) method. This method measures the amplitude of the light emitted by two beams: the cantilevers and a reference one [15]. After optical interference, the resulting intensity is not the addition of the single intensities but a modulated one. For this purpose a Polytec MSA-500 vibrometer has been used. LDVs are particularly well suited for measuring vibrations where alternative methods either reach their limits or simply cannot be applied. For example, LDVs can measure vibrations up to the 30 MHz range with very linear phase response and high accuracy (fig. 6.9.4). In addition, measurements of the surface of liquid materials or vibrations of small and light structures can also only be made using non-contact measurement techniques.

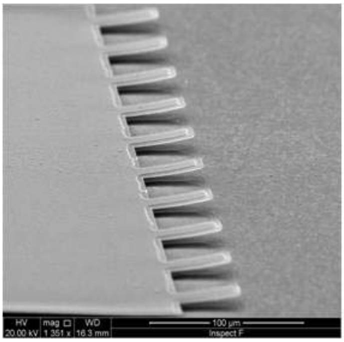

Figure 6.9.3. *SEM image of an array of cantilevers*

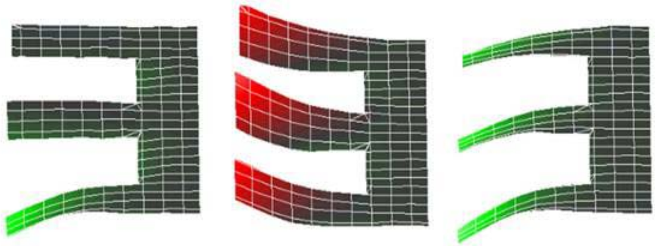

Figure 6.9.4. *Modal shapes obtained by vibrometry measurements for the 50 x 250 μm^2 cantilevers.*

References

[1] F. Calle, J. Pedrós, T. Palacios, J. Grajal, *Physica status solidi (c)* **2**, 976 (2005).

[2] B. Drafts, Acoustic Wave Technology Sensors. Retrieved from http://www.sensorsmag.com/sensors/acoustic-ultrasound/acoustic-wave-technology-sensors-936.

[3] J.C. Doll, B.C. Petzold, B. Ninan, R. Mullapudi, B.L. Pruitt, *J. Micromechanical. Microengineer*. **20**, 0250086 (2010).

[4] S.K. Vashist, *Journal of Nanotechnology online*. http://www.azonano.com/article.aspx?ArticleID=1927 (2007).

[5] G.F. Iriarte, J.G. Rodríguez, F. Calle, *Material Research Bulletin* **45**, 1039 (2010).

[6] G.F. Iriarte, J.G. Rodríguez, F. Calle, *Journal of Materials Processing Technology* **212**, 207 (2012).

[7] J.G. Rodríguez, G.F. Iriarte, D. Araujo, M.P. Villar, O. Williams, W. Müller-Sebert, F. Calle, *Mat. Lett.* **66**, 339 (2012).

[8] F. Lloret, D. Araújo, M.P. Villar, J.G. Rodríguez-Madrid, G.F. Iriarte, O. A. Williams, F. Calle, *Microelectronics Enginering* **112**, 193 (2013).

[9] J.G. Rodríguez-Madrid, G.F. Iriarte, J. Pedrós, O.A. Williams, D. Brink, F. Calle, *IEEE Electron Dev. Lett.* **33**, 495 (2012).

[10] J.G. Rodríguez-Madrid, G. F. Iriarte, O. A. Williams, F. Calle, *Sensors and Actuators: Physical A* **189**, 364 (2013).

[11] K. Krupa, M. Józwicki, A. Andrei, L. Nieradko, C. Gorecki, P. Delobelle and L. Hirsinger, *Proc. SPIE* **6995**, 699501 (2008).

[12] V. Mortet, A. Vasin, P.Y. Jouan, O. Elmazria, M.A. Djouadi, *Surf. Coat. Technol.* **176**, 88 (2003).

[13] K. Krupa, C. Gorecki, R. Jóźwicki, M. Józwik, A. Andrei, *Sensors and Actuators A: Physical*. **171**, 306 (2011).

[14] V. Lebedev, N. Heidrich, O. Bludau, F. Knöbber, C.C. Röhlig, E. Sah, L. Kirste, W. Pletschen, V. Cimalla. *Proceedings Power MEMS* 258, (2010).

[15] M. Dubois, P. Muralt, *Sensors and Actuators A: Physical*. **77**, 106 (1999).

6.10 GaN-based high electron mobility transistors (HEMTs) for communications and energy applications [10]

Fátima Romero, Fernando Calle and Elías Muñoz

ISOM has maintained during the last ten years an intense research activity on gallium nitride (GaN) based high electron mobility transistors (HEMTs). This kind of devices has already carved a dominant role in high-power and high-frequency applications [1]. The aluminum gallium nitride (AlGaN) barrier type of GaN HEMTs was the first to be implemented [2], and has been widely studied. During the last few years, important efforts have been performed by many groups to optimize so much this kind of devices. In ISOM, we have devoted attention to some of the steps of the fabrication, such as the ohmic contacts [3], dry mesa etching [4], wet etching for gate-recessed [5], gate metallization [6] and surface treatment based on N_2 plasma before passivation [7].

Nowadays, AlGaN/GaN HEMTs are offered commercially as RF products [8]. However, the reliability and heat spreading issues are still a bottleneck for their applications in communications and energy, which our group has been currently investigating on. Also, we have been working on the development of enhancement mode (E-mode, normally off) which has become a mandatory requirement for AlGaN/GaN HEMT devices designed for power switching applications.

On the other side, an alternative to the tensile strained AlGaN-barrier is a lattice matched InAlN-barrier GaN HEMT first proposed by Kuzmik [9]. The large spontaneous polarization in the InAlN barrier HEMTs ensures high electron sheet charge densities, making it possible to achieve current densities of over 2 A/mm even with thin (~10 nm) barrier films [10,11]. Recently, InAlN-barrier GaN HEMTs have improved so much that their RF characteristics match and in some cases outperform AlGaN/GaN HEMTs [10-13]. Therefore, this research activity also includes the structural characterization of this InAlN-based heterostructures (HS) and trapping effects in InAlN/GaN HEMTs. Some of the main results of this research activity are summarized in the following.

I. Thermal management in GaN-based HEMTs: self heating and heat spreading

Self-heating effects in AlGaN/GaN HEMTs grown on three different substrates have been evaluated for ambient temperatures between 0°C and 225°C [14]. A simple and accurate electrical method for the estimation of channel temperature is proposed. This technique is based on the difference in drain current between dc and short-pulsed conditions. Being an electrical method, neither special geometry nor expensive equipments are required. Simulations have also been performed to confirm the results, as shown in figure 6.10.1. This method meets the relevant requirements for the estimation of $T_{channel}$: 1) simplicity; 2) robustness; 3) reproducibility; and 4) sensitivity to the circuit design variable (geometry, structure, and so on). In addition, compared with optical techniques, it may be applied in packaged devices and does not require expensive equipment. Concerning alternative electrical methods, a reduced number of measurements are required for the determination of $T_{channel}$ even at different $T_{amb.}$

In addition, the effect of using a diamond layer on top of the HEMT devices (fig. 6.10.2.a) was extensively analyzed, in order to evaluate its *heat spreading* properties [16,17]. Steady state and transient response electrothermal coupling simulations were performed to study the thermal management of AlGaN/GaN HEMTs with diamond heat spreading layers. The simulations focused on the comparison of thermal and electrical behavior for C- and D-HEMT (control and diamond, respectively) operating in DC and pulse condition. It was shown that the device performance can be improved significantly by this top-side heat spreading, as shown in figure 6.10.2.c for both Si and SiC substrate devices. The diamond thickness and its thermal conductivity were also discussed, which illustrated that the channel temperature reduction shows saturation with the diamond thickness. Therefore, the several μm thick diamond plays an important role on

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the heat spreading ability, which also increases with larger lateral thermal conductivity of the diamond. This suggested that it is unnecessary to deposit a thick diamond layer, as the determining factor is the quality of the diamond film.

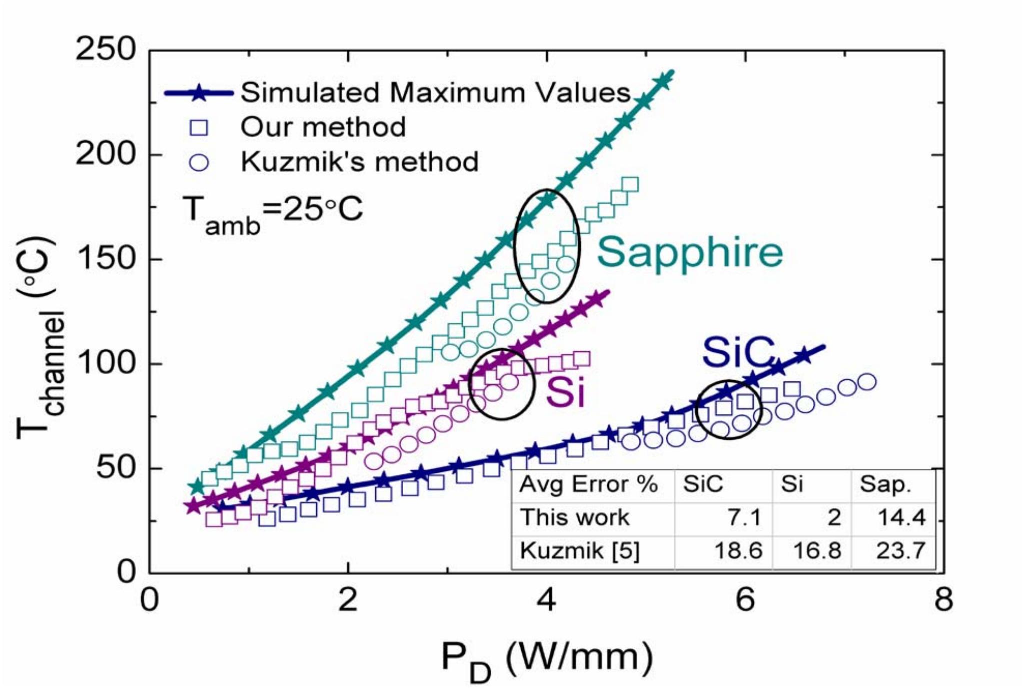

***Figure 6.10.1**. Comparison of the $T_{channel}$ vs P_D simulated maximum values and obtained applying our technique and the one explained in [15].*

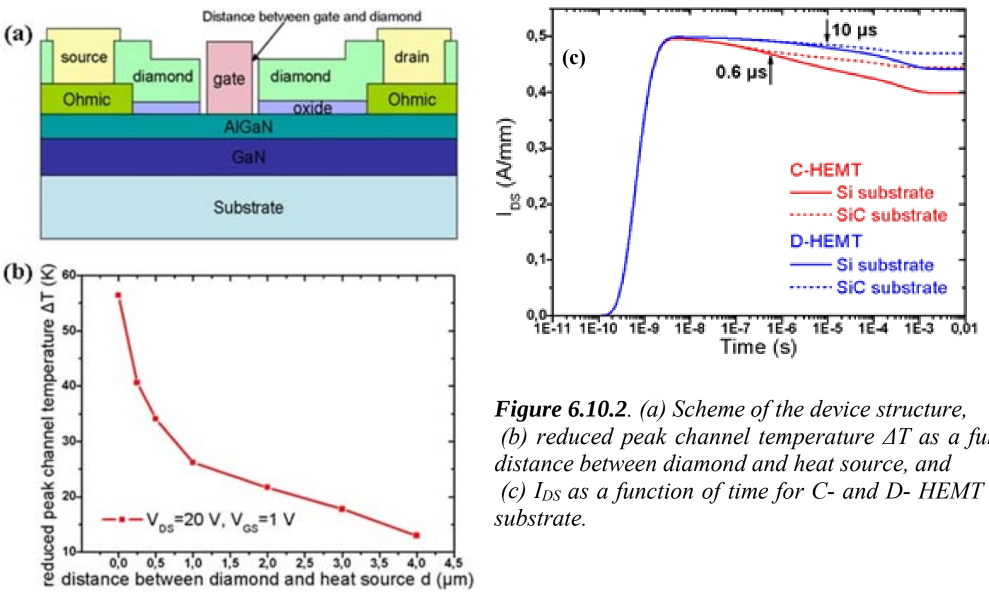

***Figure 6.10.2**. (a) Scheme of the device structure,*
(b) reduced peak channel temperature ΔT as a function of the distance between diamond and heat source, and
(c) I_{DS} as a function of time for C- and D- HEMT on Si or SiC substrate.

Due to the generated heat concentrating at the drain side of gate edge, the channel temperature reduction depends on a small volume diamond near the heat source (fig. 6.10.2.b) and less affected by the total deposited diamond.

The “diamond-before-gate” mid process fabrication method presents an advantage over other thermal management methods, since the diamond cap is close to the heat source. With this procedure, the substrate and thermal boundary resistance have a delayed impact on the electrical behavior of the device in pulsed operation condition [18]. Future work will address the investigation of this aspect. Overall, this work would provide useful guidelines to optimize the heat spreading layer design so as to make this method more feasible to the integration of device thermal management.

II. Enhanced-mode AlGaN/GaN HEMTs

E-mode AlGaN/GaN HEMT devices have been fabricated at ISOM with treatments of either CF_4 plasma or $19F^+$ implantation prior to gate deposition. The post-treatment threshold voltage V_T was shifted positively from -4.06 V to 0.25 V and -0.34 V, respectively. Subsequent 400°C, up to 10 min furnace annealing increased the transconductance g_m in both samples, leading to a two order of magnitude increase in drain current density. The implanted sample improved its V_T to -0.16 V, whereas the V_T of the CF_4 plasma-treated one reverted to -1.95 V. Annealing a commercial power HEMT (EPC1012, Efficient Power Conversion Corp.) under identical conditions resulted in stable V_T within 1.4% ($V_{T,Rated}$ = 1.4 V). As the ambient temperature was increased to 150°C, the V_T of our samples remained within 10% of the room-temperature values. Reliability stress measurements were performed by applying a V_{STRESS} of ±1 V or ±2 V for up to 10 minutes. V_T of EPC HEMTs increased with temperature and stress polarity, but remained close to specification up to the maximum rated temperature (125°C) [19].

III. InAlN/GaN HEMTs: Structural characterization and traps identification

AFM analyses carried out in semi-contact and conductive modes allowed for the identification and characterization of nanocracks in AlInN/AlN/GaN HS. It is assessed that this propagation is associated with indium segregation [20]. Current–voltage characteristics show that the nanocracks (fig.6.10.3) are electrically conductive, induce very high leakage current and strongly affect the rectifying behavior of Schottky contacts fabricated on the AlInN layer, as shown in figure 6.10.4.

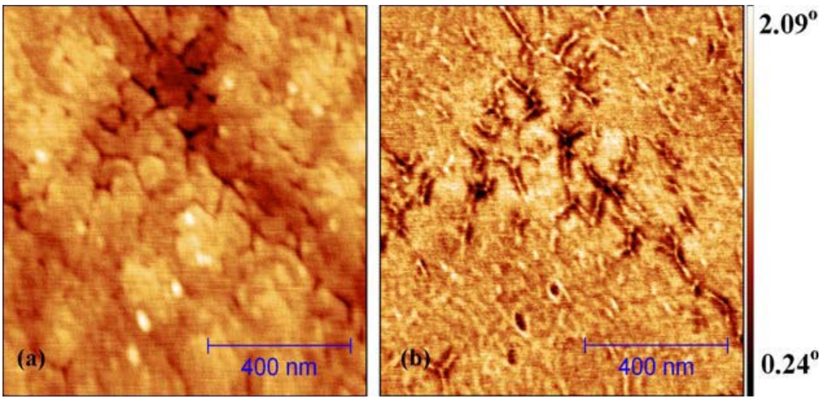

***Figure 6.10.3**. (a) Topography image of sample F (semi-contact mode AFM) showing cracks, and (b) corresponding phase image. Dark contrast regions are associated to In segregation.*

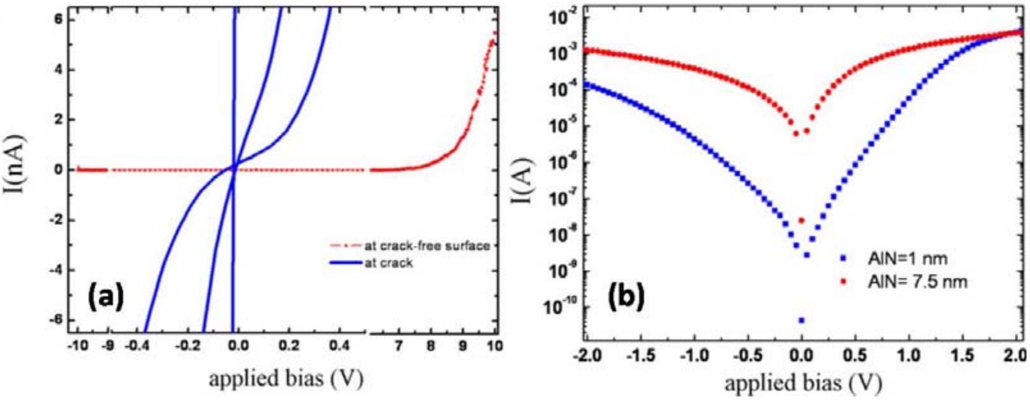

***Figure 6.10.4**. (a) Microscopic current–voltage characteristics obtained with the AFM-probe at the cracks and on a crack-free surface of AlInN/AlN (7.5 nm)/GaN heterostructures. (b) Macroscopic current–voltage characteristics of Ni/Au Schottky contacts on AlInN/AlN/GaN heterostructures with AlN layers of 7.5 nm and 1 nm.*

In addition, traps in InAlN/GaN and AlGaN/GaN HEMTS are identified and compared using constant drain-current deep level transient spectroscopy (CI_D-DLTS) [21]. For both structures with different barrier materials, the same drain-access electron trap at E_C−0.57 eV dominates the drain-controlled CI_D-DLTS trap spectrum, as shown in figure 6.10.5. This suggests that the physical source of this trap, previously associated with drain-lag, is not present in the barrier but instead is likely to reside in the GaN-buffer. Gate-controlled CI_D-DLTS measurements, which are preferentially sensitive to the barrier under the gate, reveal different trap spectra for the two HEMTs, showing that choice of barrier materials can influence under-gate trap signatures.

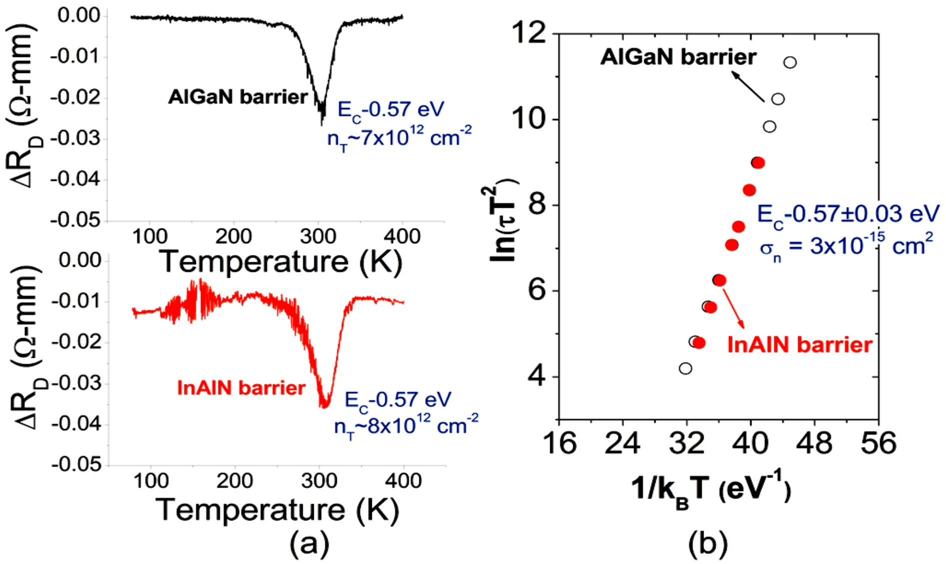

***Figure 6.10.5**. (a) Drain-controlled CI_D-DLTS spectra for 80 s^{-1} rate window of the AlGaN-barrier (top) and InAlN-barrier (bottom) HEMTs, showing a single dominant E_C–0.57 eV virtual-gate-related electron trap located in the drain-access region. (b) Arrhenius data of the E_C–0.57 eV from both HEMTs showing excellent overlap, indicating that both HEMTs have the same defect signature. The low temperature (100-200 K) features in the InAlN-barrier HEMT CI_D-DLTS is related to noise in the measurement.*

On the other hand, InAlN/GaN HS with different In contents have been systematically analysed by PL measurements for temperatures between 5K and RT [22]. A luminescence peakis found associated to the recombination between electrons in the 2DEG at the second level ($E_{n=2}$) and photoexcited holes in the GaN buffer. These findings are supported by the good correlation between the experimental transition energies and model calculations. The dependence of the 2DEG-related emission on the In content can be understood with the changing band profile attributed to the different polarization gradient between InAlN and GaN.

IV. GaN-based HEMTs applications

GaN-based HEMTs for different applications have been fabricated and tested, including sensors and amplifiers.

(a) *pH-sensors using InAlN/GaN* HS [23]

The pH response of GaN/AlInN/AlN/GaN ion-sensitive field effect transistor (ISFET) on Si substrates was characterized. The variation of the surface potential (ΔVsp/ΔpH) and current (ΔIds/ΔpH) with solutions in devices with the same In content (17%, in-plane lattice-matched to GaN) and different AlInN barrier thickness (6 nm and 10 nm), were analyzed and compared with the literature. The shrinkage of the barrier, that has the effect to increase the transconductance of the device, makes the 2-dimensional electron density at the interface very sensitive to changes in the surface.

Although the surface potential sensitivity to pH is similar in the two devices, the change of current with pH (ΔIds/ΔpH), when biasing the ISFET by a Ag/AgCl reference electrode, is almost 50% higher in the device with 6 nm AlInN barrier, compared to the device with 10 nm barrier. When measuring the current response (ΔIds/ΔpH) without reference electrode, the device with thinner AlInN layer has a larger response than the thicker one, in a factor of 140%, and that current response without reference electrode is only 22% lower than its maximum response obtained using reference electrode. In summary, the AlInN barrier ISFET with a lattice-match thin barrier and grown on silicon is a very promising candidate for chemical sensors which can be integrated with CMOS technology.

(b) *Power amplifier supply for RF power amplifiers* [24]

Implementation and testing of noncommercial GaN FET in a simple buck converter for envelope amplifier in envelope tracking (ET) and envelope elimination and restoration (EER) transmission techniques has been done. The prototypes with commercially available EPC1014 and 1015 devices showed significantly worse thermal management and problems with power dissipation disabled the operation at switching frequency higher than 10 MHz. In contrast, implemented prototypes with noncommercial devices provided significantly better thermal management and increased switching frequency, up to 25 MHz, as shown in figure 6.10.6. The obtained efficiency was 38% including the driving circuit and the total losses breakdown showed that switching power losses in the FET are the dominant ones. This implies that minimization of the gate charge is the key issue in the optimization of the devices for this kind of application.

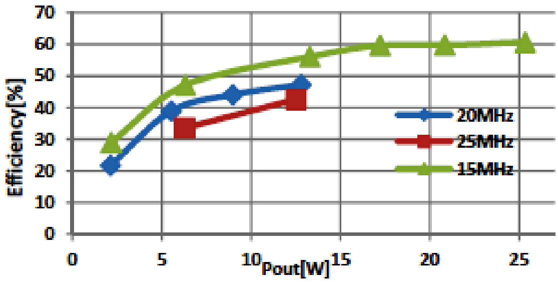

***Figure 6.10.6**. Efficiency curves for prototype measured at 15, 20 and 25MHz.*

References

[1] U. K. Mishra, P. Parikh, and Y. F. Wu, *Proc. IEEE* **90**, 1022 (2002).

[2] M. A. Khan, A. Bhattarai, J. N. Kuznia, and D. T. Olson, *Appl. Phys. Lett*. **63**, 1214 (1993).

[3] A. Redondo-Cubero, M.D. Ynsa, M.F. Romero, L.C. Alves, and E. Muñoz, *Nucl. Instr. Meth. Phys. Res. B* **306**, 212 (2013).

[4] Z. Gao, M.F. Romero, and F. Calle, *IEEE Sp. Conf. Electr. Dev.* **2013**, 29 (2013).

[5] T. Brazzini, M.J. Tadjer, Z.Gacevic, S.Pandey, A.Cavallini, and F. Calle, *Semicond. Sci. Technol.* **28**, 055007 (2013).

[6] M.F. Romero, M.J. Uren, M.J. Tadjer, C. Dua, A. Jiménez, R. Cuerdo, F. Calle, and E. Muñoz. *Submitted for publication.*

[7] M.F. Romero, A. Jiménez, F. González-Posada, S. Martín, F. Calle, and E. Muñoz. *IEEE Trans. Electron Dev.* **59**, 374 (2012).

[8] T. Kikkawa, K. Makiyama, T. Ohki, M. Kanamura, K. Imanishi, N. Hara, and K. *Joshin, Phys. Status Solidi A* **206**, 1135 (2009).

[9] J. Kuzmik, *IEEE Trans. Electron Devices* **22**, 510 (2001).

[10] H. Wang, J. Chung, X. Gao, S. Guo, and T. Palacios, *Phys. Status Solidi C* **7**, 2440 (2010).

[11] D. S. Lee, J. W. Chung, H. Wang, X. Gao, S. Guo, P. Fay, and T. Palacios, *IEEE Electr. Dev. Lett.* **32**, 755 (2011).

[12] F. Medjdoub, J.-F. Carlin, M. Gonschorek, E. Feltin, M. A. Py, D. Ducatteau, C. Gaquière, N. Grandjean, and E. Kohn, *IEEE IEDM Tech. Dig.* **2006**, 1.

[13] N. Sarazin, E. Morvan, M. A. di Forte Poisson, M. Oualli, C. Gaquière, O. Jardel, O. Drisser, M. Tordjman, M. Magis, and S. L. Delage, *IEEE Electr. Dev. Lett.* **31**, 11 (2010).

[14] S. Martin-Horcajo, A. Wang, M.F. Romero, M.J. Tadjer, and F. Calle. *IEEE Trans. Electron. Dev*. **60**, 4105 (2013).

[15] J. Kuzmik, P. Javorka, A. Alam, M. Marso, M. Heuken, and P. Kordos, *IEEE Trans. Electr. Dev*. **49**, 1496 (2002).

[16] A. Wang, M.J. Tadjer, F. Calle, *Semicond. Sci. Technol.* **28**, 055010 (2013).

[17] A. Wang, M.J. Tadjer, T.J. Anderson, R. Baranyai, J.W. Pomeroy, T.I. Feygelson, K.D. Hobart, B.B. Pate, F. Calle, M. Kuball, *IEEE Trans. Electron Dev* **60**, 3149 (2013).

[18] A. Sarua, H. Ji, K. P. Hilton, D. J. Wallis, M. J. Uren, T. Martin, and M. Kuball. *IEEE Trans. Electr. Dev.* **54**, 3152 (2007).

[19] M. J. Tadjer, S. Martín-Horcajo, T. J. Anderson, R. Cuerdo, K. D. Hobart, and F. Calle. *Physica Status Solidi c*, **8**, 2232 (2011).

[20] A. Minj, D. Cavalcoli, S. Pandey, B. Fraboni, A. Cavallini, T. Brazzini, and F. Calle. *Scripta Materialia* **66**, 327 (2012).

[21] A. Sasikumar, A. R. Arehart, S. M. Horcajo, M. F. Romero, Y. Pei, D. Brown, F. Recht, M. A. di Forte-Poisson, F. Calle, M. J. Tadjer, S. Keller, S. P. DenBaars, U. K. Mishra, and S. A. Ringel. *Appl. Phys. Letters* **103**, 033509 (2013).

[22] M.F. Romero, M. Feneberg, P. Moser, C. Berger, J. Bläsing, A. Dadgar, A. Krost, E. Sakalauskas, and R. Goldhahn*. App. Phys. Lett*. **100**, 212101 (2012).

[23] T. Brazzini, A. Bengoechea, M.A. Sánchez-García, and F. Calle. *Sensors & Actuators: Chemical B* **176**, 704 (2013).

[24] D. Cucak, M. Vasic, O. Garcia, J. Oliver, P. Alou, J. A. Cobos, M. Tadjer, F. Calle, F. Benkhelifa, R. Reiner, P. Waltereit, and S. Muller. *IEEE Applied Power Electronics Conference* (APEC Digest) **2013**, pp. 664.

6.11 Modeling of soft condensed matter and complex fluids [11]

Manuel Laso

During the last four years, modeling activities in the soft matter simulation group has focused on the investigation of the mechanisms and hindrances of crystallization in systems of athermal and soft-sphere chains. We give an overview of the most relevant results of our recent modeling work on packings of freely-jointed chains of tangent hard spheres, on the MRJ state, local structure, chain dimensions and their scaling with density, topological constraints in the form of entanglements and knots, contact network at jamming, and entropically driven crystallization.

I. Nearly jammed systems of athermal polymers

Dense packings of chains of hard (athermal) spheres possess characteristic features that do not have a counterpart in similar packings of monomeric spheres. Connectivity endows the maximally random jammed (MRJ) state of hard-sphere chains with additional structural characteristics derived from chain conformation which are absent in monoatomic systems. At the MRJ state, the additional requirement that spheres keep their connectivity while maximizing the occupied volume fraction imposes severe constraints on generation algorithms. The extremely sluggish dynamics imposed by the uncrossability of chains precludes the use of deterministic or stochastic dynamics to generate all but dilute athermal polymer packings. As a viable alternative, especially tailored chain-connectivity-altering Monte Carlo (MC) algorithms have been developed that bypass this kinetic hindrance and have actually been able to produce packings of hard spheres in a volume fraction range spanning from infinite dilution up to the MRJ state. Such very dense packings have been found to share a number of structural features with packings of monomeric hard-spheres, but also to display unique characteristics.

II. Packing chains of hard spheres with chain-connectivity-altering MC

Given the increasing inefficiency of deterministic dynamics methods to generate and relax packings of hard spheres at high volume fractions, Monte Carlo schemes become a natural choice. In these methods, individual system configurations along the underlying Markov sequence need not to be related by a physical move, in the sense of lying along a deterministic dynamic trajectory. As a matter of fact it has been repeatedly observed that the more “unphysical” the moves in an MC scheme are, the faster the sampling of configuration space becomes for chains, so long as the basic rules of proper MC (microscopic reversibility, volume preservation in phase-space) are obeyed [1, 2]. In particular, in MC it is allowed to break and re-connect chains, which is tantamount to allowing chains to cross each other. This bypass of chain uncrossability is the key to fast relaxation.

Devising MC schemes that perform this kind of large-scale rearrangement of chains yet are statistic-mechanically correct, and numerically efficient, although not an entirely trivial matter, is feasible. Another attractive feature of MC is that several sampling methods can be combined at will in an MC scheme, so long as the rules of the game are obeyed.

This flexibility in the mixing of different MC schemes is of paramount importance since no single MC algorithm working in isolation is able to generate random chain packings with anywhere near acceptable efficiency at (though some recent generation algorithms are very efficient at intermediate to high volume fractions [3, 4]). However, by using a carefully chosen combination and modification of several state-of-the-art MC algorithms for efficient structural relaxation of both short- and long-range structural features we have succeeded in producing very dense packings up to the neighborhood of the MRJ state [5]. Figures 6.11.1 is a representative snapshot of highly compact chains in the vicinity of the MRJ state. Figure 6.11.2 shows unfolded and periodically folded chains for the largest system of hard monomer chains produced to date [6].

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III. Chain conformation

Connectivity endows the MRJ state of hard-sphere chains with additional structural characteristics, like bond and torsion angle distributions, and chain conformation, which are obviously absent in monoatomic systems. As a general trend, described in the previous section, chains undergo a progressive decrease in overall size, often described as “chain collapse”, as volume fraction increases. This collapse is the consequence of chains adopting conformations which are much more compact and coiled than those of isolated ones, in order to efficiently pack at higher volume fractions. At vanishingly low volume fractions (dilute regime), the bending angle distribution is determined by highly localized and purely intramolecular constraints. As packing density increases, chains start to interact and size reduction takes place, with intermolecular and higher-order intramolecular interactions being responsible for specific conformations to appear. At the MRJ chain collapse reaches its maximum extent, and very compact chain conformations constitute the overwhelming majority of the members of the ensemble. Chain compactness is reflected in the bond bending and torsional angle distributions which develop characteristic maxima (and minima) at specific values.

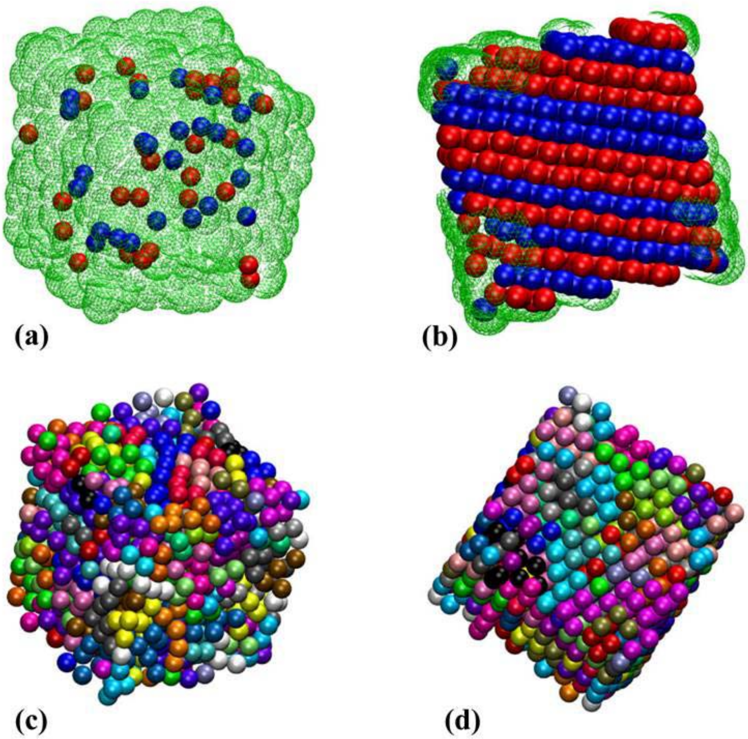

Figure 6.11.1. *System configuration of hard-sphere chains at where the majority of sites possesses a highly ordered local environment. Spheres belonging to individual chains have the same color. The wireframe grid indicates the underlying crystalline structure.*

In the case of the bending angle distribution, these maxima correspond to the most frequent arrangement of three consecutive spheres (two consecutive bonds) along a chain at 60º and 120º. In a similar manner, the maxima in the distribution of torsion (dihedral) angles, defined by four consecutive spheres (three successive bonds) also correspond to specific four-sphere arrangements leading to the characteristic peaks at 0º, 54.7º, 70.5º, 109.5º and 180º torsion angles.

The three (bending angle), or four (torsional angle) spheres occupy sites belonging to a locally dense, regular structure. The existence of these peaks indicate that at the MRJ state, there is an appreciable tendency for short sequences of chain monomers to fold into the locally densest possible conformation, although the overall structure remains homogeneous and isotropic, in accordance with the nature of the metastable branch of the phase diagram that ends at the MRJ state. These loci of incipient order correspond to the geometry of the polytetrahedral model of disordered packings of monomeric hard spheres. For monoatomic packings at the MRJ, most of the spheres belong to at least one moderately perfect polytetrahedral arrangement. Indeed, the maxima in the bond bending and torsion angle distributions are due to three (bending) or four (torsion) consecutive spheres belonging to one or two connected tetrahedra.

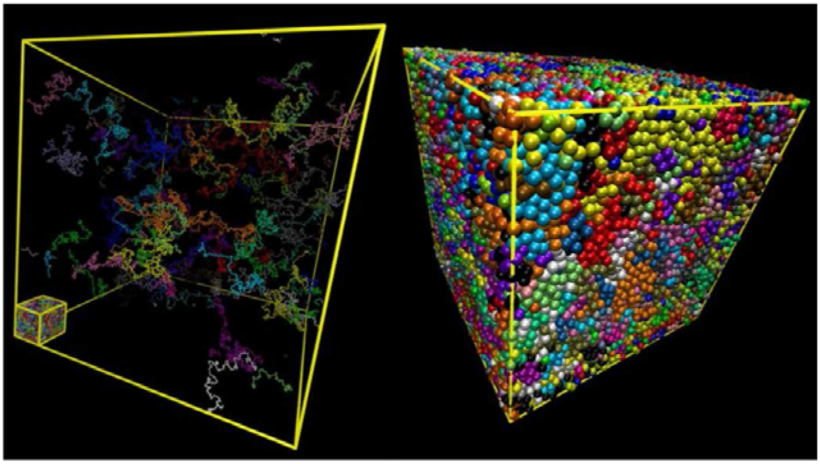

Figure 6.11.2. *Large system configuration in the vicinity of the MRJ. At left the chains are shown in their unfolded conformations. . The small cube in the lower left corner contains the same chains but after having been folded using periodic boundary conditions. The image at right is a magnification of the small box at left. Chains colored by identity (all monomers belonging to a given chain have the same color).*

The prevalence of bending and torsional angles that produce compact chain conformations, implies that there exist several other values of bending and torsional angles that lead to inefficient space occupation, for example, the 90º. These inefficient conformations appear with much reduced frequency when compared with the distributions for isolated chains [7].

IV. Contact network

Jammed random packings of hard-sphere chains are especially useful in the detection of structural features involving higher number of spheres. A good example is the shared-neighbor analysis of single sphere packings [3]. This analysis requires the detection of contacts in packings generated with a very strict numerical tolerance.

Our ensembles of chains in the close vicinity of the MRJ state show a remarkable feature: the distribution of the end-to-end vector displays a strong maximum corresponding to chains forming closed loops.This effect is present for all chain lengths. The existence of contact rings at the MRJ is a consequence of "chain collapse", and of the abundance of very compact chain conformations.

In a randomly selected polymer configuration at the MRJ state as much as 8% of the chains adopt loop (ring) conformations. Similar analysis performed on MRJ configurations of monomeric hard spheres found open clusters of up to five contacting spheres to be frequent, but did not detect loop conformations [3]. It is likely that the unsuccessful search for closed chains may have been caused by the practical impossibility of carrying out a graph analysis to the required depth (tolerance for the detection of contact neighbors is up to machine accuracy). The strength of using the ensembles of chains for elucidating such "far-neighbor" structural issues, is that intramolecular ("inherent") neighbors are trivially known by construction as a direct consequence of chain connectivity, so that no search analysis is required, and numerical precision is not a limitation.

V. Tetrahedral nature of the MRJ

The existence of helicoidal and polytetrahedral structures in random packings of monoatomic spheres has been postulated in an attempt to elucidate the nature of the MRJ state itself. It is widely accepted that the existence and relative stability of the metastable branch ending in the MRJ state is due to the conflict between the local tendency of spheres to form tetrahedral aggregates, and the impossibility to fully tesselate 3D space with tetrahedra. Evidence of this space-filling frustration has been provided for monomeric sphere packings by monitoring the evolution in the fraction of spheres that belong to tetrahedral aggregates as the volume fraction is increased.

A similar analysis for hard-sphere chain packings corresponding to the infinite-length regime shows that the fraction of spheres that belong to at least one tetrahedron does indeed grow as the MRJ is approached [6]. However, this rapid increase stops as a volume fraction of   is reached, after which the number of spheres associated in tetrahedral clusters actually decreases. In monoatomic sphere packings the number of tetrahedral aggregates grows monotonically all the way up to the MRJ. Thus, polymer packings behave in this respect quite differently from monoatomic ones, in agreement with recent statistical mechanical predictions. For chains, the rapid increase in the marginal regime is a consequence of the chains "thickening" or "roughening" by side accretion at constant end-to-end distance, a phenomenon absent in monomeric analogs. For chains, the decrease in the number of spheres belonging to tetrahedral aggregates is triggered by individual chains starting to interact and compete for accretion of further monomers.

VI. Scaling behavior of chain size with volume fraction

Apart from the determination and characterization of the MRJ state for chains, the proposed MC scheme made it possible to systematically study the scaling behavior of chain size as a function of packing density from infinitely dilute concentrations up to the MRJ state. We observed that global chain size descriptors, such as radius of gyration, and end-to-end distance display a strong and non-trivial dependence on volume fraction. Especially as concentration approaches the MRJ state major long- and short-range conformational changes take place. In agreement with theoretical expectations [2,6], we identified four distinct concentration regimes where chain dimensions (quantified by the characteristic ratio exhibit distinct scaling behaviours. All simulation-based scaling exponents, even for short chains, nicely confirmed long standing renormalization group theoretical predictions [3, 4]. These values were insensitive to chain length for chains longer than six monomers. While the cross-over concentration depends strongly on chain length, successive threshold values were found to be chain-length independent to first order in molecular length. It could thus be established that freely-jointed chains of tangent hard spheres are the simplest, non-trivial model of linear molecular systems that displays the full range of universal scaling behavior. It is also remarkable that this series of results at widely varying volume fractions could all be obtained with the same MC scheme.

VII. Knotting vs. entanglement

The extreme simplicity of hard-sphere chains makes them an ideal statistical mechanics model on which to analyze the effect of concentration on topological constraints, mainly in the form of inter-chain entanglements. The concept of entanglements lies deep in the core of all successful molecular theories, like the "tube model", the "reptation theory" and their extensions, proposed to capture the unique dynamical and rheological properties of polymeric systems. From the modeling perspective various algorithmic approaches have been proposed on how to transform the physical concept of entanglements according to Doi-Edwards into a mathematical one of robust topological principles.

The primitive path (PP) of a polymer chain is defined as the shortest path connecting the chain ends which obeys all topological constraints of uncrossability imposed by all other chains and nano-inclusions. In our work, primitive paths were extracted from the corresponding ("parent") hard-sphere chains by means of the Z1 algorithm which adopts a direct geometrical approach for the identification of entanglements. The evolution of entanglement density with polymer volume fraction is of particular interest, since the complex, non-intuitive dependence of the number of entanglements on gives rise to the very different types of rheological behavior which have been observed experimentally as concentration increases up to the melt.

A different approach to analyze the topology of individual polymer chains is through the study of knots and their complexity. Individual chains were extracted from the configurations generated by the MC algorithm and their knotting was determined using a technique based on the concept of knot group, which is simultaneously more discriminating and easier to calculate than the knot invariants that have been used in such studies in the past (Gauss winding number, or the Alexander, Jones, or HOMFLY polynomials). Since the simulated polymer systems consist of linear chains a scheme is necessary to convert the linear chain into a closed polygon. It has been shown that the scaling results on the polymer knotting have been unaffected by the various techniques adopted for the chain closure.

Figure 6.11.3 shows in double logarithmic plot the scaling dependence of the average number of primitive path segments (entanglements) and of the knotting probability as a function of packing density for the N = 1000 chain system. It can be seen clearly that within the statistical uncertainty both entanglements and knots show exactly the same concentration trends and corresponding scaling exponents. Such surprising results unmistakably points towards a strong correlation between entanglements, which are intermolecular constraints, and knots, which constitute form of intramolecular topology.

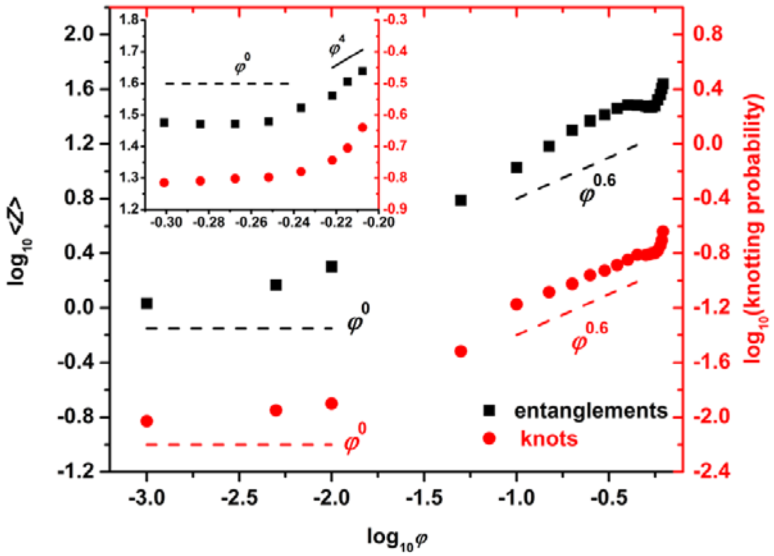

Figure 6.11.3. *Double logarithmic plot of the (left axis) average number of segments of the primitive path and of the (right axis) fraction of knotted chains for the N = 1000 hard sphere chain system. Lines with characteristicslopes are drawn as guides to the eye. Inset: zoom into the marginal and concentrated regimes. M. Laso, N. C. Karayiannis, K. Foteinopoulou, M. L. Mansfield and M. Kröger, Soft Matter, 5, 1762, 2009 – Reproduced by permission of The Royal Society of Chemistry.*

By construction, entanglements are highly localized in space, whereas knotting is a global, "delocalized" property of a chain. Still, by showing exactly the same scaling behavior in these ideal polymer systems it is established that both variations of chain topology are intimately related so that an analysis of one kind could provide information about the other and would ideally allow for a mapping between collective chain properties and ones of individual properties. This remarkable similarity may not be that surprising after all: although the analyses of knotting and entanglement seem to be totally unrelated at first sight, the essential information both of them ultimately require is contained in the succession of over- and under-crossings of two-dimensional projections of the chains, in the case of entanglements, or of a single chain in the case of the knotting.

References

[1] N. C. Karayiannis, K. Foteinopoulou, C. Abrams and M. Laso, *Soft Matter* **6**, 2160 (2010).

[2] K. Foteinopoulou and M.Laso, *Ultrasonics* **50**, 758 (2010).

[3] G. N. Toepperwein, N.C. Karayiannis, R.A. Riggleman, M. Kröger, J.J. de Pablo, *Macromolecules* **44**, 1034 (2011).

[4] N. C. Karayiannis, R. Malshe, J.J. de Pablo, M. Laso, *Physical Review E* **83**, 061505 (2011).

[5] Nikos Ch. Karayiannis, Rohit Malshe, Martin Kroger, Juan J. de Pablo and Manuel Laso, *Soft Matter* **8**, 844 (2012).

[6] Nikos Ch. Karayiannis, Katerina Foteinopoulou and Manuel Laso, *International Journal Molecular Science* **14**, 332 (2013).

[7] Robert S. Hoy, Nikos Ch. Karayiannis, *Physical Review E* **88**, 012601 (2013).

[8] Nikos Ch. Karayiannis, Katerina Foteinopoulou and Manuel Laso, *Philosophical Magazine* **93**, 4108 (2013).

6.12 Fabrication of Magnetic Nanoparticles by Magnetron Sputtering [12]

Mar Sanz Lluch and Marco Maicas

One of the research lines at ISOM concerns the fabrication of magnetic nanoparticles by the gas aggregation technique using magnetron sputtering sources [1]. This technique is a modification of the classical thin film sputtering coating process. The sputtering source is located inside a vacuum chamber (aggregation chamber) with a small hole. A high pressure of an inert gas, typically Ar, is injected in the chamber producing an outflowing of this gas through the orifice (fig. 6.12.1c). The pressure in the

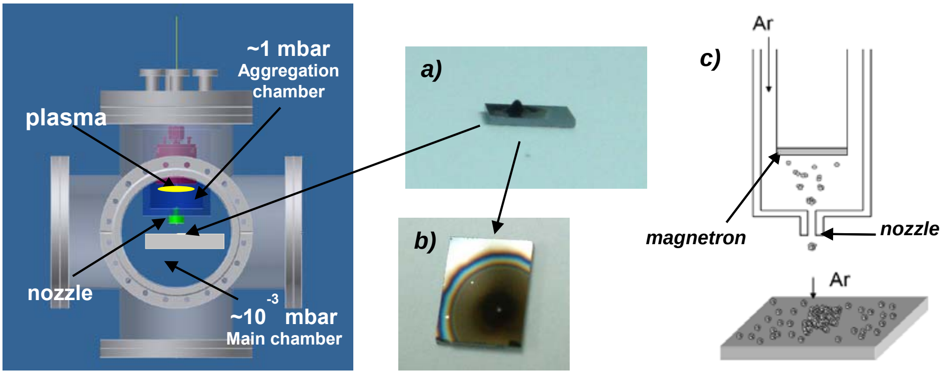

Figure 6.12.1. *Sputtering nanoparticles synthesis set-up. a) deposit profile; b) interference pattern at the edge of the deposit; c) carrier gas flow.*

aggregation chamber is high enough to reduce the mean free path of the sputtered atoms increasing the number of collisions and promoting the synthesis of nanoclusters. Such nanoclusters are carried out by the inert gas flux and collected in another vacuum chamber with a lower pressure (fig. 6.12.1). Nanoparticles are typically deposited on silicon substrates (fig.6.12.1.a and 6.12.1.b) for their further characterization.

A quartz microbalance is used to control growing rates by a rotating substrate holder. Such a system has been developed at ISOM [2] for the synthesis of magnetic nanoparticles (fig. 6.12.2) as well as the needed techniques for the characterization of the deposits obtained [3]. This new design does not require differential vacuum chamber, as it is used in the commercial set-ups. In this system the aggregation chamber has its own independent pumping system, therefore the growing pressure can be decreased and better controlled. The plasma can also be monitored during the growth.

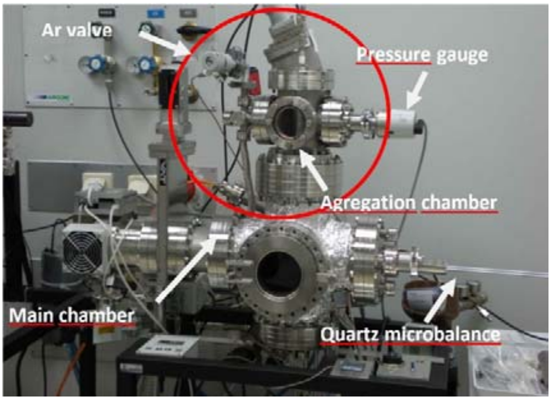

Figure 6.12.2. *Nanoparticle deposition system at ISOM. Aggregation and main chambers have independent pumping systems.*

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I. Pure magnetic element Nanoparticles

High magnetization nanoparticles (Cobalt and Iron)

The growing parameter that mainly controls the size of the nanoparticles is the gas pressure. In the case of Co nanoparticles, for growing powers about 40-45W, we find practical limits in pressures ranging from 0.07 mbar and 2.2 mbar; the higher the pressure the larger the nanoparticle size. However, nanoparticles diameter changes abruptely at a pressure of 1.2 mbar. For higher pressures, particles diameters are particularly large, reaching sizes above 200 nm (fig. 6.12.3). This suggests the existence of a different mechanism leading to the formation of large agglomerations.

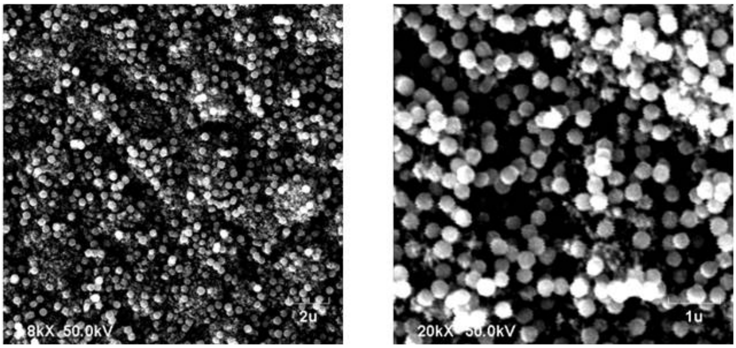

***Figure 6.12.3**. Co nanoparticles at high pressure regime*

Typical dimensions obtained in the low pressure regime ranges from 10-20nm. We observe that nanoparticle dimensions cannot be reduced even decreasing the growing power to the lower values (<0.1mbar). Cobalt hysteresis loops (fig. 6.12.4.a) exhibit a large coercivity even for the smallest nanoparticles with dimensions close to the superparamagnetic limit. This result can be attributed to the large magnetization of those nanoparticles and the fact that they are in contact in the deposit.

Measurements on Fe nanoparticles lead to similar results (fig. 6.12.4.b). Deposits do not exhibit superparamagnetic behavior even for the lowest nanoparticle dimensions.

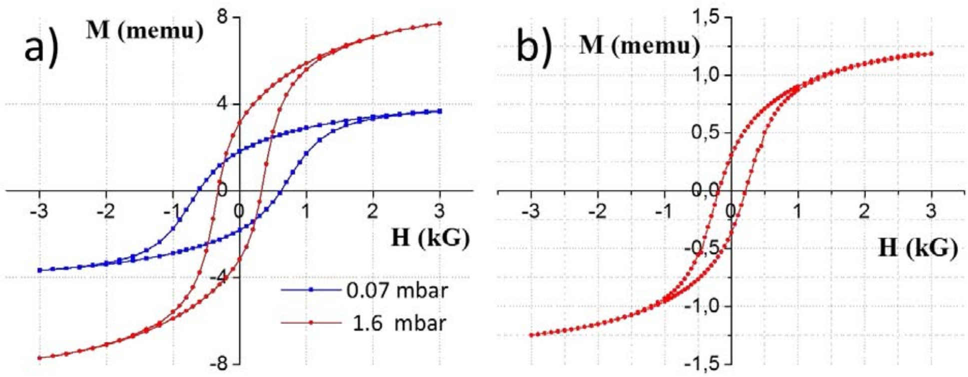

***Figure 6.12.4.** Hysteresis loops of a) Co and b) Fe nanoparticles at different growing pressures.*

Low magnetization nanoparticles (Nickel)

In the case of Ni nanoparticles, practical limits are found between 0.2 and 1 mbar for the low pressure regime. In this case, nanoparticle diameters range from 20 and 50 nm [2]. On the contrary of the high magnetization nanoparticles, Ni nanoparticle grown exhibit superparamagnetic behavior for the lowest pressures (0.2 mbar). In this case the interaction between nanoparticles is not as strong as that in high magnetization materials and the superparamagnetic effect prevails leading to a notably reduction in coercivity (fig. 6.12.5) below the sensitivity of the measuring equipment (VSM).

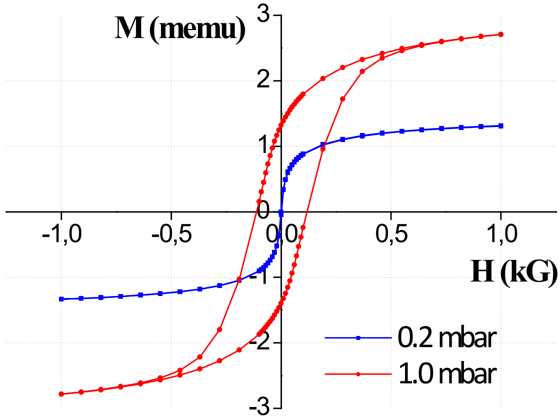

Figure 6.12.5. *Hysteresis loops of Ni nanoparticles*

II. Core-shell nanoparticles (Fe-Au)

One of the interesting topics research in the fabrication of nanoparticles by the gas aggregation technique is the possibility of synthesizing core-shell structures. To achieve these structures, experiments with compound material targets have been made [4]. These techniques use targets containing both two materials, for the nucleus and for the shell. Process is based on the different binding energies of the two materials, leading to a segregation of the two species, by raising the concentration of one species in the nucleus and the other in the shell. This kind of nanoparticles are potentially very interesting for biomedical applications due to the possibility of using large magnetization materials for the nucleus and a biocompatible covering shell [5].

Experiments carried out at ISOM with Fe-Au targets led to nanoparticles with dimensions ranging from 5 (0.3 mbar) to 16 nm (0.9 mbar). TEM microscopy reveals good size dispersion and VSM measurements exhibit very low coercivities (fig. 6.12.6). These are good properties, however, the distribution of Fe and Au in the nanoclusters is not well defined, which is probably the reason why there is a reduction in coercivity when compared to those of pure iron with similar dimensions.

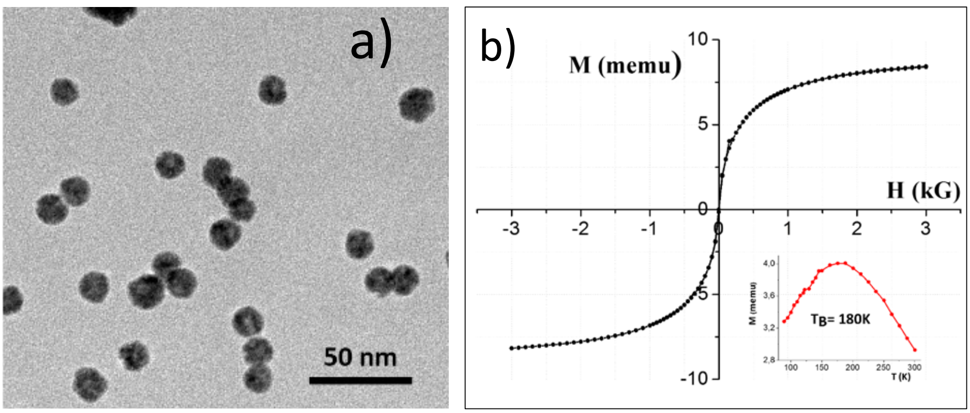

Figure 6.12.6*. Fe-Ni Nanoparticles: a)TEM image; b) Magnetic response at room temperature and magnetization at low temperatures.*

Research on the synthesis of core-shell nanoparticles by the gas aggregation technique is now being focused on including an additional step in the fabrication process. This step consists in including a coating chamber where the nanoparticle beam passes through (fig. 6.12.7). This chamber has a region with a high density of atoms of the coating material [6]. This technique looks promising and some new designs have been carried out [7] even using the same aggregation chamber [8-9]. However, there is still scarce information about the quality of the core-shell nanostructures obtained.

At ISOM work is pursued on the development of new magnetrons with very low dimensions to substitute the coating chamber stage. The main difficulty for such magnetron sources is the problem of obtaining a good plasma within such a small volume. On the other hand, the advantage is the high density of coating atoms that can be obtained. First results working with this type of magnetrons have been successful for diameters about ∅5mm which look promising for the fabrication of this kind of structures.

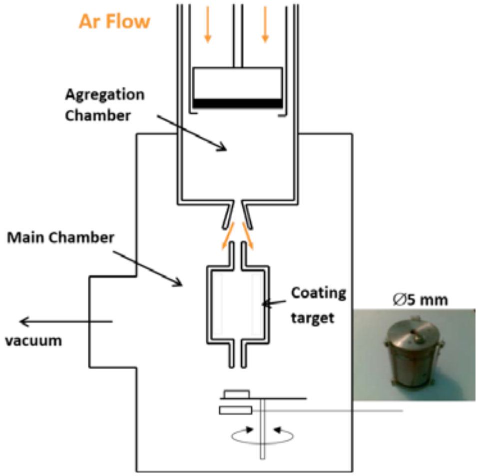

Figure 6.12.7. *Set up at ISOM for core-shell nanoparticle fabrication*

References

[1] H. Haberland, M. Mall, M. Moseler, Y. Qiang, T. Reiners and Y. Thurner, *J. Vac. Sci. Technol*. **12**, 2925 (1994).
[2] M. Maicas, M. Sanz, H. Cui, C. Aroca, and P. Sánchez, *Journal of Magnetism and Magnetic Materials* **322**, 3485 (2010).
[3] P. Cobos, M. Maicas, M. Sanz, and C. Aroca, *IEEE Transactions on Magnetics* **47**, 2360 (2011).
[4] Y.-H. Xu and J.-P. Wang, *Advanced Materials* **20**, 994 (2008).
[5] T. L. Kline, Y.-H. Xu, Y. Jing, and J.-P. Wang, *Journal of Magnetism and Magnetic Materials* **321**, 1525 (2009).
[6] J. Bai and J.-P. Wang, *Applied Physics Letters* **87**, 152502 (2005).
[7] http://www.mantisdeposition.com/?url=nanocoatings
[8] L. Martínez, M. Díaz, E. Román, M. Ruano, D. Llamosa P and Y. Huttel, *Langmuir* **28**, 11241 (2012).
[9] http://www.oaresearch.co.uk/oaresearch/nc200/

6.13 Size, strain and band-offset engineering in InAs/GaAs quantum dots for improved photonic devices [13]

José María Ulloa

The unique optical and electronic properties of semiconductor self assembled quantum dots (QDs) promise to overcome some of the principal limitations of current photonic technologies. Due to the strong 3D confinement of the carriers inside these zero-dimensional nanostructures, electronic energy levels are fully quantized and such quantum character is manifested even in the ensemble behaviour, thus allowing the realization of photonic devices with improved characteristics. Within this framework, the possibility of engineering the electronic structure of QDs is crucial for many applications. The approach followed at ISOM is to tune the band structure of InAs/GaAs QDs by a modified thin capping layer containing Sb and/or N. The technique used to fabricate the structures is molecular beam epitaxy.

I. Tuning the QD band structure through a thin GaAsSb capping layer

The origin of the modified optical properties of InAs/GaAs QDs capped with a thin $GaAs_{1-x}Sb_x$ layer is analyzed in terms of the band structure. To do so, the size, shape, and composition of the QDs and capping layer are determined through cross-sectional scanning tunneling microscopy (X-STM) and compared to PL measurements and the results of a 8x8 k·p model [1]. X-STM allows investigating the QD structural properties at the atomic scale as well as a precise determination of the Sb content in the capping layer, and this can be directly related to the PL of the same QD layer (figures 6.13.1.a and 6.13.1.b). Therefore, a quite realistic structure can be used as the input for the k·p calculations (figures 6.13.1.c and 6.13.1.d).

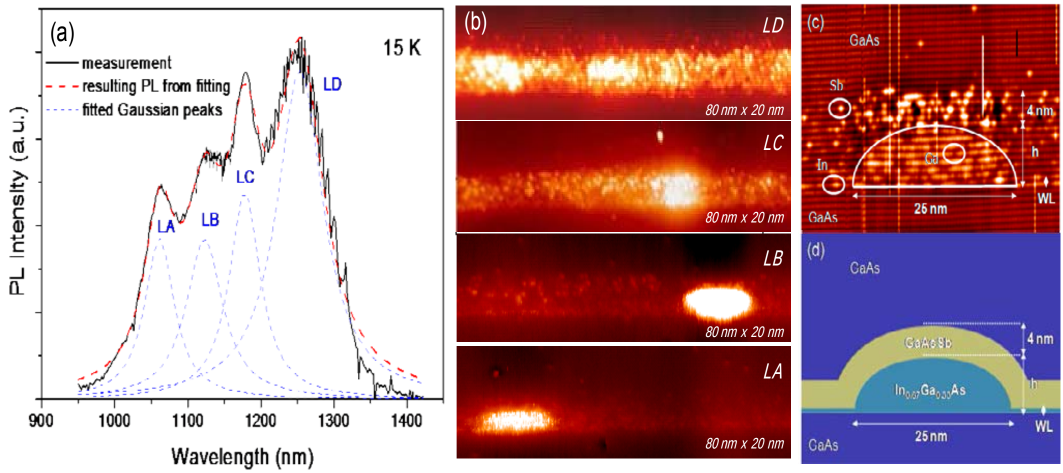

***Figure 6.13.1**. (a) 15 K PL spectra of a sample with four QD layers designed for X-STM measurements. (b) X-STM topography images (V= -3 V) of the four different QD layers. The GaAsSb layer with higher amount of Sb appears brighter in the image. One QD can be observed in each of the first three layers. (c) High resolution image of a QD in LD (22 % Sb). The brighter spots correspond to Sb atoms in the As matrix and the dark features inside the QD indicate the presence of Ga. (d) Sketch of the QD structure considered in the calculations. The QD height (h) increases with the Sb content up to 14 % Sb and then remains constant.*

As the Sb content is increased, there are two competing effects determining carrier confinement and the oscillator strength: the increased QD height [2] and reduced strain on one side (as also observed for InGaAs-capped QDs [3]) and the reduced QD-capping layer valence band (VB) offset on the other. Nevertheless, the observed evolution of the PL intensity with Sb cannot be explained in terms of the oscillator strength

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between ground states, which decreases dramatically for Sb>16%, where the band alignment becomes type II with the hole wavefunction localized outside the QD in the capping layer (figure 6.13.2).

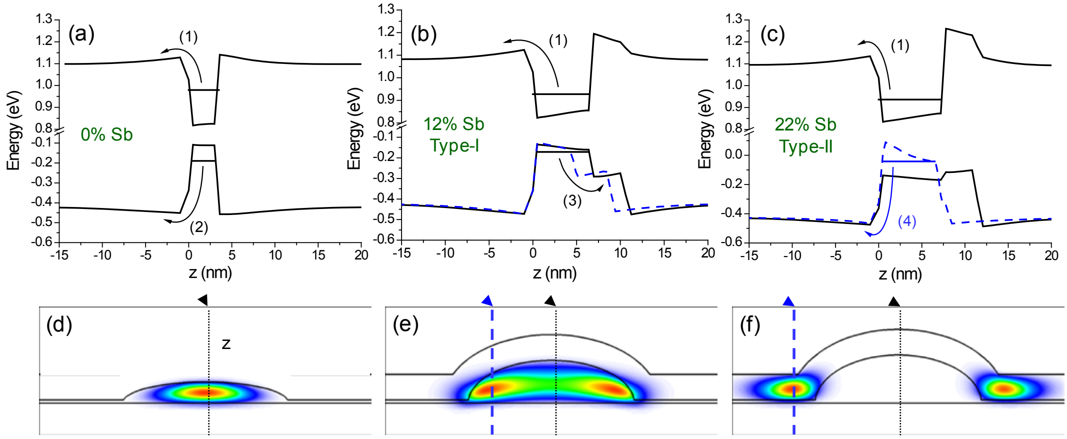

Figure 6.13.2. (a) to (c) Calculated CB and VB edge profiles in the growth direction (z) across the center of the QD (black continuous lines), together with the energy of the electron and hole ground states. In the case of samples with 12 and 22% Sb, the VB edge profile is plotted also across a line close to the side of the QD base (blue dashed line in the figures below). (d) to (f) show the distribution probability of the ground state hole wavefunction in the (1-10) plane.

Contrary to this behaviour, the PL intensity in the type II QDs is similar (at 15 K) or even larger (at room temperature) than in the type I Sb-free reference QDs (figure 6.13.3.a). This indicates that the PL efficiency is dominated by carrier dynamics, which is altered by the presence of the GaAsSb capping layer. In particular, the presence of Sb leads to an enhanced PL thermal stability (inset in figure 6.13.3.a). From the comparison between the activation energies for thermal quenching of the PL and the modeled band structure, the main carrier escape mechanisms are suggested (fig. 6.13.3.b).

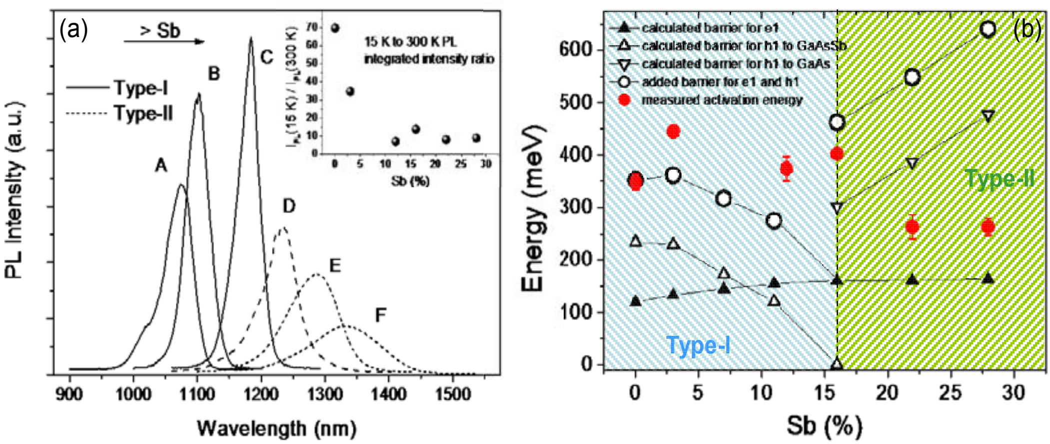

Figure 6.13.3. (a) 15 K PL spectra from the QD layers with increasing amount of Sb in the capping layer. The inset shows the ratio between the PL integrated intensity at 15 K and 300 K as a function of the Sb content. (b) Measured PL activation energy together with the calculated energy barriers for the electron ground state, the heavy hole ground state, and the addition of the calculated barriers for electron and hole ground states (added barrier for e1 and h1), as a function of the Sb content.

In standard GaAs-capped QDs, escape of both electrons and holes to the GaAs barrier is the main PL quenching mechanism. For small-moderate Sb (<16%) for which the type I band alignment is kept, electrons escape to the GaAs barrier and holes escape to the GaAsSb capping layer, where redistribution and retraping processes can take place. For Sb contents above 16% (type-II region) holes remain in the GaAsSb layer and the escape of electrons from the QD to the GaAs barrier is most likely the dominant PL quenching mechanism. This means that electrons and holes behave dynamically as uncorrelated pairs in both the type-I and type-II structures.

The unexpectedly strong PL emission from the type-II samples despite the reduced oscillator strength can still be improved by post-growth thermal treatments [4]. Indeed, the PL efficiency of GaAsSb-capped InAs/GaAs type II QDs can be greatly enhanced by rapid thermal annealing (RTA) while preserving long radiative lifetimes which are ~20 times larger than in standard GaAs-capped InAs/GaAs QDs. Despite the reduced electron-hole wavefunction overlap, the type-II samples (sample Sb-RTA) are more efficient than the type-I counterparts (Ref sample) in terms of luminescence, showing a great potential for device applications (figure 6.13.4).

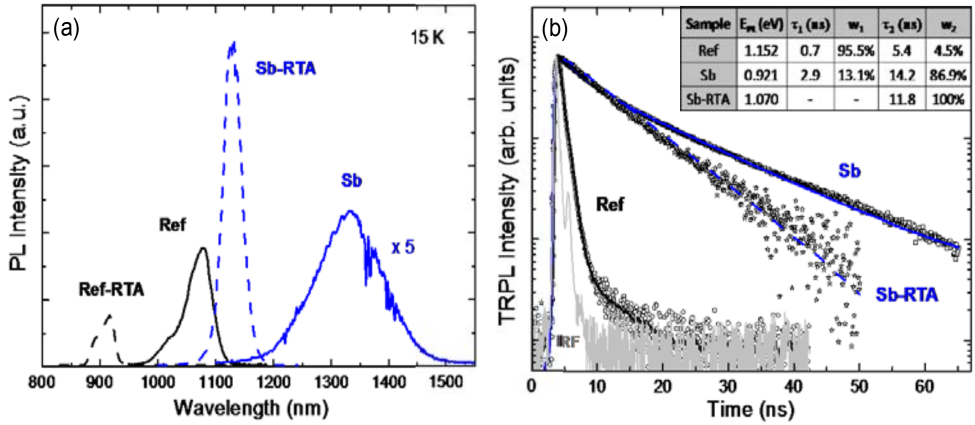

Figure 6.13.4. *(a) 15 K PL spectra of samples Ref, Ref-RTA, Sb and Sb-RTA. (b) PL decay transients of samples Ref, Sb and Sb-RTA measured at the PL maximum. The IRF was measured with an ultrafast laser diode emitting at 950 nm. Inset table with PL peak energy, the obtained radiative lifetimes and corresponding weights for the three samples.*

The morphological changes undergone during the RTA process are revealed by transmission electron microscopy (TEM) measurements. Strain-driven In-Ga intermixing during annealing is found to modify the QD shape and composition, giving rise to flatter QDs with a higher Ga content, and the QD size distribution becomes narrower (Fig. 6.13.5). Nevertheless, As-Sb exchange is inhibited, allowing keeping the type-II structure. Sb is only redistributed within the capping layer giving rise to a more homogeneous composition on top of the QDs, which should also contribute to reduce the PL full width at half maximum (FWHM).

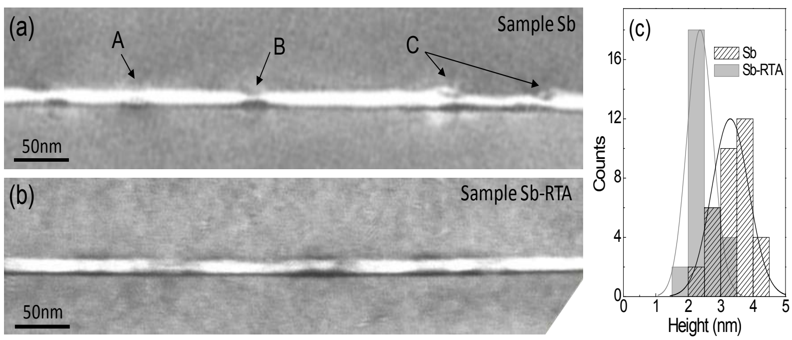

Figure 6.13.5. *g002 dark field TEM images of samples Sb (a) and Sb-RTA (b). (c) shows the measured QD height distribution in both samples.*

II. Independent tuning of the QD band offsets: GaAsSbN capping layer

A step forward to increase the degrees of freedom in tuning the band structure of InAs/GaAs QDs would be to add N to the capping layer. It is demonstrated that covering InAs/GaAs QDs with a thin GaAsSbN layer allows an independent and controlled modification of the electron and hole confinement potentials through the N and Sb contents, respectively [7].

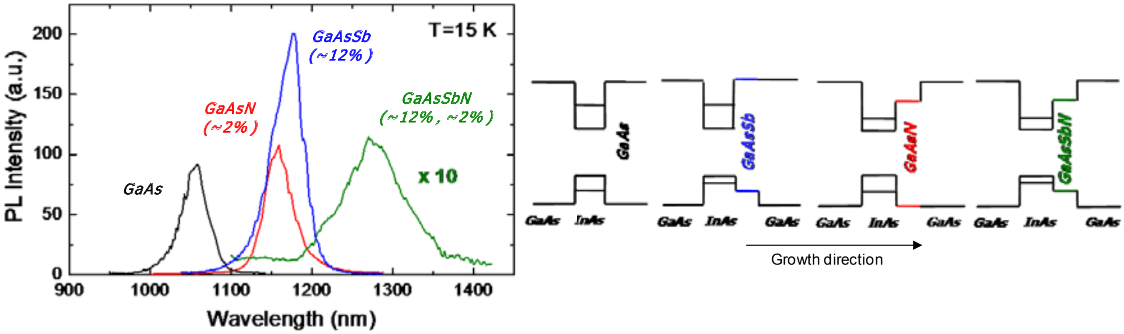

***Figure 6.13.6**. 15 K PL spectra of four InAs/GaAs QD layers capped with different materials: GaAs, GaAsSb, GaAsN and GaAsSbN. Sketch of the expected band structure in each case.*

This is due to the fact that, while Sb mainly modifies the VB of GaAs only, N modifies only the conduction band (CB) of GaAs, inducing a strong reduction of the CB edge energy for small N contents (fig. 6.13.6). Since there is no strain reducing effect in this case, the strong red-shifts observed in the PL spectra when adding N to the capping layer are due to the reduced QD CB offset. Moreover, this QD-capping layer system shows a huge versatility for band structure engineering, allowing tuning of the band alignment from type-II in the VB (high Sb content) to type I and to type-II in the CB (high N content) (fig. 6.13.7).

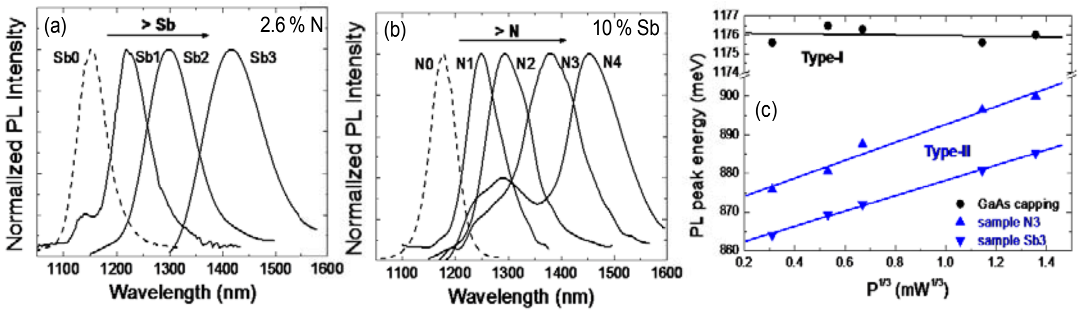

***Figure 6.13.7.** 15 K PL spectra of the series of samples with increasing N (a) and Sb (b). (c) shows the PL peak shift as a function of the third root of the excitation power for the reference sample (GaAs-capped QDs) and samples Sb3 and N3. The lines are linear fits to the data.*

This great versatility in tuning the band structure makes this system a very promising candidate for many optoelectronic applications and could open the doors to new future applications of InAs/GaAs QDs requiring different band alignments. However, high resolution TEM strain analysis show that the simultaneous presence of Sb and N gives rise to strain and composition inhomogeneities that degrade the PL of the structure (fig. 6.13.8) [8]. The presence of a small amount of N gives rise to a strong reorganization of the capping layer. This composition modulation is associated to mass transport phenomena that take place during growth and could be avoided by modifying the growth conditions.

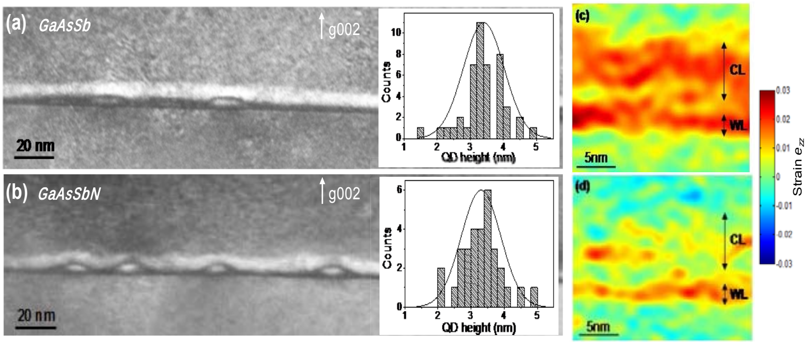

***Figure 6.13.8**. g002 dark field TEM images of samples with GaAsSb (a) and GaAsSbN (b) capping layer. Insets: measured QD height distribution in each case. (c) And (d) show the strain maps obtained from HRTEM images acquired along the [011] zone axis of samples S-Sb and S-SbN, respectively.*

III. Improved photonic devices through QD band structure engineering

The band structure tuning through QD height, strain and band alignment engineering described above can give rise to photonic devices with improved characteristics, in particular LEDs and LDs.

A series of LEDs with active layers based on GaAsSb-capped InAs QDs was fabricated by standard processing techniques [5]. By varying the Sb content in the capping layer from ~2 to ~28%, room temperature electroluminescence (EL) from 1.15 to 1.5 μm is obtained (fig. 6.13.9.a). The external efficiency of the devices increases as the Sb is increased up to ~15% and then decreases for higher Sb contents (Fig. 6.13.9.b), consistently with the reported increase of QD height with the Sb content up to ~14% [2] and the band alignment transition from type I to type II above ~16% Sb described above [1]. Sb-containing LEDs are in any case more efficient than the standard GaAs-capped counterparts, showing also significantly longer EL wavelengths which cover the telecom region.

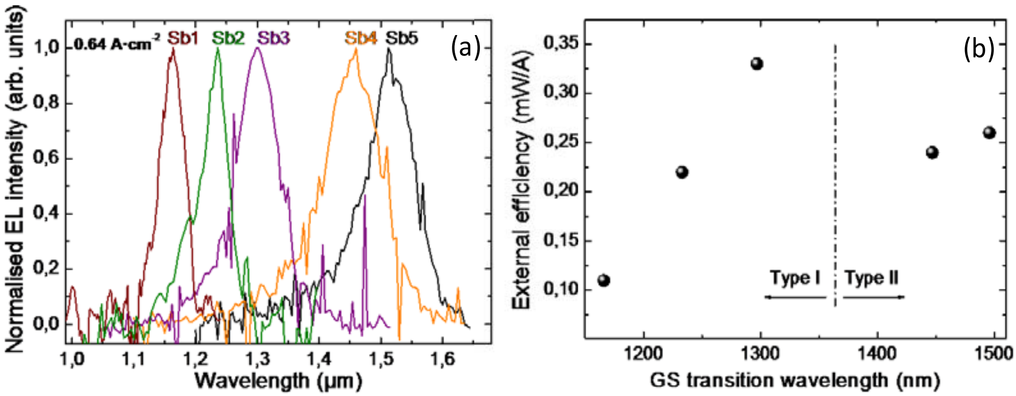

***Figure 6.13.9**. (a) Normalized room-temperature EL spectra of the InAs/GaAsSb QDLEDs. Spectra taken at 160 mA cm^{-2}, except for Sb_1, in which a current of 640 mA cm^{-2} was necessary to obtain detectable EL. (b) Maximum values of the external efficiency as a function of the maximum ground state (GS) EL peak wavelength.*

Type I and type II band alignment InAs/GaAs QD LDs are also demonstrated using a 5-nm-thick GaAsSb capping layer with moderate or high Sb contents (0, 8 and 18 % Sb, called Sb_0, Sb_8 and Sb_{18}, respectively) [6]. The lasing wavelength red-shifts with the Sb content, but it is shorter than expected due to lasing from excited states (figures 6.13.10.a and 6.13.10.b). This effect is particularly important in the type II QD LDs, in which the ground state transition is inhibited in the amplified spontaneous emission (ASE) likely due to the presence of the junction built-in electric field. Due to the wavefunction distribution in type II

QDs, the electric field will push the electrons downwards, deeper into the QDs, and the holes upwards towards the top GaAsSb/GaAs interface. This will strongly increase the spatial separation of their wavefunctions and the carrier lifetime and therefore will reduce the oscillator strength, resulting in the observed inhibition of the ground state transition.

Despite this, the threshold current density (J_{th}) is strongly reduced by using a GaAsSb capping layer, whereas the differential external quantum efficiency (η_d) is substantially improved for moderate Sb contents in the type I band alignment region (figure 6.13.10.c). Moreover, the characteristic temperature (T_0) is strongly enhanced in the type-II samples (figure 6.13.10.d). Indeed, T_0 as high as 130 K were found for high Sb contents in the type II region.

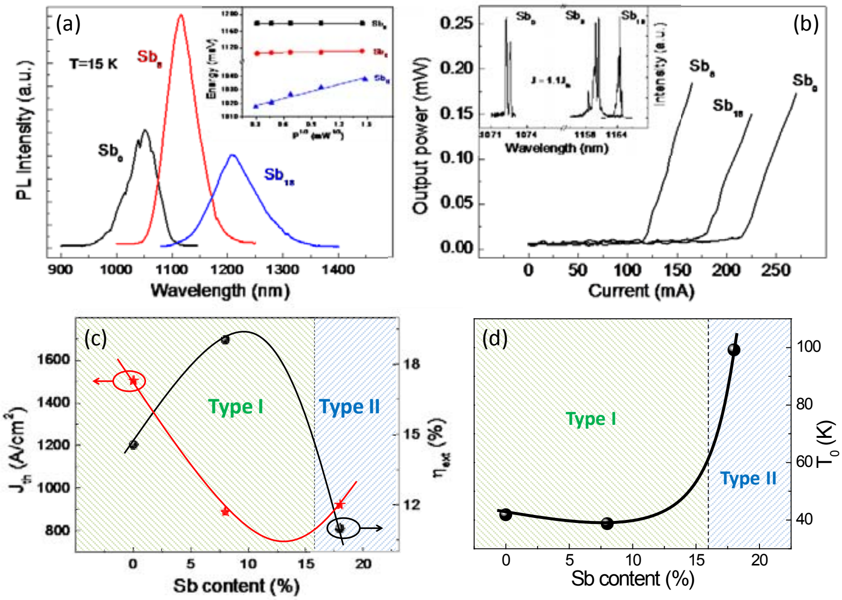

Figure 6.13.10. *(a) Low temperature PL spectra for samples Sb_0, Sb_8, and Sb_{18}. The inset shows the peak energy as a function of the third root of the excitation power. (b) Light vs. current curves for L_c=1300 μm. The inset shows laser spectra slightly above threshold for the three devices. (c) J_{th} and η_{ext} for lasers with L_c=1000 μm as a function of the Sb content. (d) characteristic temperature T_0 vs Sb content in the capping layer. Lines are guides to the eye.*

References

[1] J. M. Ulloa, J. M. Llorens, M. del Moral, M. Bozkurt, P. M. Koenraad, and A. Hierro, *J. Appl. Phys.* **112**, 074311 (2012).

[2] J. M. Ulloa, R. Gargallo-Caballero, M. Bozkurt, M. del Moral, A. Guzmán, P. M. Koenraad, and A. Hierro, *Phys. Rev. B* **81**, 165305 (2010).

[3] J. G. Keizer, P. M. Koenraad, P. Smereka, J. M. Ulloa, A. Guzman, and A. Hierro, *Phys. Rev. B* **85**, 155326 (2012)

[4] J. M. Ulloa, J. M. Llorens, B. Alen, D. F. Reyes, D. L. Sales, D. Gonzalez, and A. Hierro, *Appl. Phys. Lett.* **101**, 253112 (2012)

[5] M. M. Bajo, J. M. Ulloa, M. del Moral, A. Guzman, and A. Hierro, *IEEE J. Quantum Electron.* **47**, 1547 (2011).

[6] A. D. Utrilla, J. M. Ulloa, A. Guzman, and A. Hierro, *Appl. Phys. Lett.* **103**, 111114 (2013).

[7] J. M. Ulloa, D. F. Reyes, M. Montes, K. Yamamoto, D. L. Sales, D. Gonzalez, A. Guzman, and A. Hierro, *Appl. Phys. Lett.* **100**, 013107 (2012).

[8] Daniel F Reyes, David González, Jose M Ulloa, David L Sales, Lara Dominguez, Alvaro Mayoral and Adrian Hierro, *Nanoscale Res. Lett.* **7**, 653 (2012).

6.14 Suppression of the intrinsic stochastic pinning of domain walls in magnetic nanostripes [14]

José Luis Prieto

The Group of Magnetic Devices within the ISOM has been working in the last few years on the stochastic motion of magnetic domain walls (DW) in magnetic nanowires and in spin transfer on different nanodevices. Here we present the main results showing that there is a regime in the movement of DWs where, with minimum energy, the DW moves unimpeded.

The demand for higher areal densities on magnetic memories led to the introduction of novel concepts such as Race-Track memory [2]. This memory functions by moving the bits of information themselves (magnetic domains) rather than by spinning the disc under the reading head. Each magnetic domain is separated by a magnetic domain wall (DW) that can be moved with an external magnetic field or with a spin polarized current, being the second option the one with real interest for practical applications. Understandably, in a future commercial device, the DW would have to move reliably between engineered pinning sites millions of times, without ever getting stuck on the inevitable structural defects (crystalline defects, grain texture, edge roughness, etc). For other applications like magnetic logic [1], or radio-frequency generation by the oscillation of a DW, the exact position of the DW must also be achieved and determined very reliably.

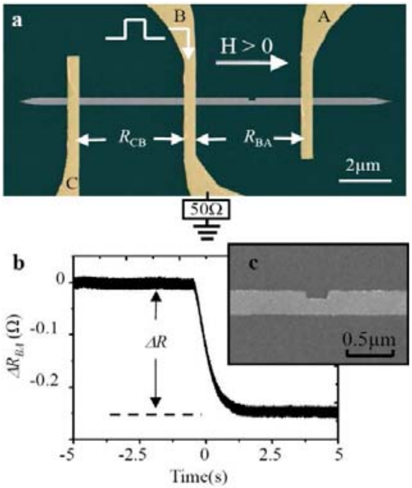

Figure 6.14.1. *SEM picture of the device (a) Resistance measurement showing the drop on AMR (b) when the DW is injected and pinned in a square notch (c)*

It is well known that in macroscopic magnetic elements, the DW travels in small discontinuous steps known as the Barkhausen jumps, caused by the pinning and subsequent release of the DW from the defects in the materials. Similarly, in magnetic nanostripes (the basic constituent of the above mentioned applications) the DW motion is also troubled by defects [3,4]. Low anisotropy materials like Permalloy ($Ni_{80}Fe_{20}$) are generally used to study the DW motion in magnetic nanostripes, although materials with perpendicular-to-plane anisotropy are also attractive due to enhanced effect of the polarized current on the movement of the DW. Both types of materials suffer from uncontrolled DW pinning [5,6] and, especially in the case of materials with perpendicular-to-plane anisotropy, even time-dependent thermal depinning.

Recent studies on DW pinning on notch-free Permalloy nanostripes [4,7,8] have evidenced the stochastic nature of the DW motion. Whether the DW pinning is avoidable or intrinsic to the propagation of DWs in real nanostripes is a matter of debate and concern. Here it is shown that the DW stochastic pinning follows three different field regimes that match the DW propagation modes, indicating that it might indeed be intrinsic to the nature of the DW motion in nanostripes. On the other hand it is also shown that the stochasticity of the DW pinning can be suppressed at very low fields and the DW transmission in a soft Permalloy nanostripe can be a perfectly reliable. Interestingly the pinning probability reaches its maximum value at intermediate fields (10 to 35 Oe) and it is constant (independent of the external field) in this range of fields.

In the last two years, the Group of Magnetic Devices of the ISOM (GDM) has started an active research in the field of Spintronics. At the end of 2007 we had a new home made sputtering system with 7 magnetron targets, specially designed for the very precise deposition of metallic multilayers. Additionally, thanks to the

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new nanolithography facility (CRESTEC CABL 9500C) at ISOM it was possible to pattern magnetic samples in small wires and devices and study the interaction of the current and the field with confined magnetic Domain Walls. This work presents examples of some of the complicated structures we deposit and of some of the measurements we are currently doing with magnetic domain walls in patterned nanowires.

This study has been done on several permalloy nanostripes, all 10 nm thick and 300 nm wide. The stripe has two sections, one with a notch and the other without any (intentional) defect (figure 6.14.1.a). A conductive current line is placed in the center and perpendicular to the stripe. A current pulse flowing through this central contact (length from 5 to 100 ns) nucleates a pair of DW that, in the presence of a positive magnetic field, travel in opposite directions [9]. The presence of a DW on any of the sections of the stripe can be detected by the drop in resistance associated with its Anisotropic Magnetoresistance. Figure 6.14.1.b shows the drop in resistance produced by the injection of a DW in section AB, when a current pulse is sent through the central current line. The integration time used to detect the resistance of the DW is 2s, which is much longer than the time required for the DW to travel through the entire length of the nanostripe (tens of nanoseconds). Therefore, when a DW is detected by this method, it is at rest pinned somewhere along the stripe.

The DW traveling to section AB is likely to get pinned at the notch. The detection of this DW allows us to be certain that the current pulse successfully injected a pair of DWs for a given pulse amplitude and that one of them travelled through section BC. Note also that the pulse current only flows through the conductive current line and not through the magnetic nanostripe. Only the current used to measure the resistance of sections AB and BC flows through the nanostripe and it is too small to interfere with the movement of the DW by spin transfer (20 μA or $7\cdot10^{5}$ A/cm^{2}).

First, the efficiency of the current pulse to inject a pair of DW is analyzed. Figure 6.14.2.a shows the probability of detecting a DW pinned at the notch (section AB) for a range of pulse amplitudes and magnetic fields. The conversion factor for the current pulse is $1.45\cdot10^{8}$ Acm^{-2}V^{-1}. As shown in figure 6.14.2.a, the probability of pinning a DW at the notch is 1 for all pulse amplitudes. Figure 6.14.2.a gives an idea of how reliable the process of injection of a DW is. The resistance of the DW at each pinning event can be recorded so we know the type of DW present in our stripes. The histograms in figure 6.14.2.c-e, show the four values of DW resistance in our stripes. The two lower values (0.19 and 0.23 Ω) correspond to transversal DW (TW) each of different symmetry and the two higher values (0.29 and 0.32 Ω) are vortex DW (VW) each of different chilarities [10].

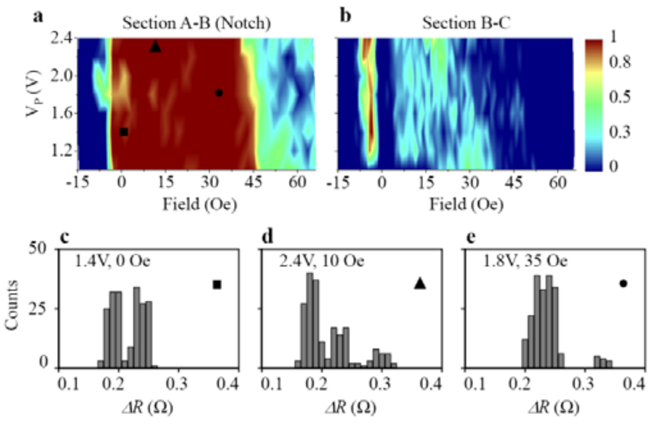

***Figure 6.14.2**. Contour plot showing the probability of pinning a DW in section AB (a) and BC (b) of the nanostripe pictured in Fig.1a, versus the voltage amplitude. Histograms showing the different types of DW for different injection conditions (c),(d) and (e).*

For a nanostripe without a notch, intuitively one might expect zero probability for pinning a DW. As can be seen from figure 2b this is far from being true. The probability of pinning is 1 for slightly negative fields, then drops to zero for small positive fields and rises again to probabilities ranging from 0 to ~0.5 before it finally drops to zero for fields larger than 50 Oe. This non-zero probability for the pinning of the DW on the section of the stripe without a notch could be put down to bad stripe quality, there being many fabrication defects that act as pinning sites. However, this cannot be the reason as there is a zone at low positive fields where the probability of pinning is zero (i.e. the DW travels through the stripe without ever pinning).

In order to better understanding the behavior of the DW traveling through a stripe without a notch, the resistance at each pinning event was recorded. Figure 6.14.3.a shows the probability of pinning for the section BC of the stripe for a 1.4V pulse and different pulse lengths. Figure 6.14.3.b shows the resistance map for all the pinning events for the case of a 1.4V-10ns injection pulse. Again in figure 6.14.3.a very distinctive regimes are observed, depending on the external magnetic field. For slightly negative fields, the probability is 1 and the type of DW is always transversal (ΔR=0.19 Ω). This is the region where the injected DW gets pinned just by the conductive current line that acts as a pinning site. Only for fields more negative than -8 Oe, the DW can pass underneath the current line and implode with the other DW. For positive magnetic fields from 0 to ~3 Oe, the probability drops to zero, indicating that the DW is transmitted reliably through section BC of the stripe (the one without the notch). More than 10 different nanostripes were measured with the same dimensions, for different amplitudes of the injection pulse (from 1.2 to 2.4 V) and different lengths (from 5 to 100 ns). Taking into account all the measured devices, the probability of pinning in the low field range was recorded for many thousands of injection events (an "event" is the successful injection of a DW, whether it gets pinned or not) and have not found a single pinning event in the range from 0.6 to 2.7 Oe. This shows that the stochastic propagation of a DW in a magnetic nanostripe can be totally suppressed at very low fields. Note that this range of perfect reliability in the transmission probability can easily be missed in stripes of lower quality where the propagation field is 2 Oe or more, as it has been observed in some stripes with abnormally high edge roughness or strong random defects. It can also be missed in experiments that use electrical current to induce the DW motion, where the critical current (minimum current necessary to achieve DW motion by spin transfer) might be equivalent to a higher field range [11].

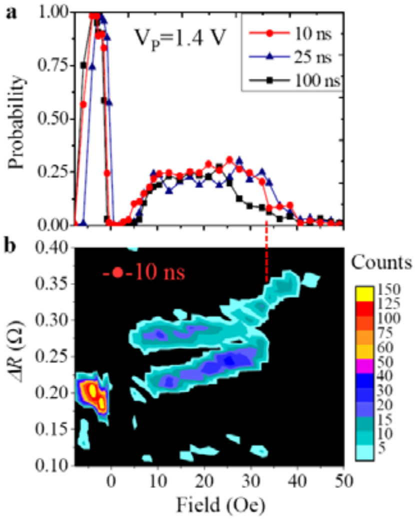

Figure 6.14.3. *Pinning probability (0 to 1) for the section BC of the nanostripe versus the external magnetic field for different pulse lengths (a) Contour plot made out of the histograms of resistivity (b)*

Now attention is paid on the increase of the pinning probability for higher fields. Figure 6.14.3.a shows that for fields higher than 3 Oe the probability of pinning rises gradually until it plateaus just over 0.2 for fields larger than 10 Oe. The probability drops again for fields larger than 35 Oe until it reaches zero after 50 Oe. As mentioned above, the type of DW nucleated in these experiments is always transversal (ΔR=0.19 Ω). On the other hand, as it can be seen in figure 6.14.3.b, after 3 Oe the pinning events distribute between vortex DW (ΔR=0.29 Ω) and transversal DW (ΔR=0.23 Ω). Also the resistance of the TW increases slightly as the field increases, indicating that its shape is slightly different for the pining events at higher fields. Additionally at 35 Oe, where the pinning probability starts to drop, the transversal DW is never found among the pinning events, leaving only increasingly resistive DW as the magnetic field gets larger.

The regions of pinning just described match well with the different DW propagation modes: translational mode up to the Walker breakdown (around 10 Oe for this type of stripes), precessional mode up to about 20-30 Oe and a turbulent mode for higher fields. These field values were obtained from previous simulations [9] and match well with other experimental reports in permalloy nanostripes of the same [2,12] or even different dimensions [13,14]. In the translational mode, the structure of the DW is stable during its displacement. In the current case, as the nucleated DW is always transversal, it should travel keeping its transversal structure for very low fields. In the precessional mode, for fields larger than about 10 Oe, the DW undergoes periodic transformations, from TW to VW [15,16]. Finally, in the turbulent mode [17], vortex and anti-vortex DW are nucleated in the stripe and at the edges, undergoing gyrotropic motions and annihilations as they travel.

The type of DW wall that gets pinned at each field (fig. 6.14.3.b) matches well with these different modes. As the field approaches 10 Oe, both types of DWs get pinned as both are present in the precessional mode. Interestingly, after 10 Oe, the pinning probability stays constant with the field and both types of DWs are found in the pinning events. This again agrees with having a precessional mode in the DW motion as the average DW velocity changes very little with the external field during this regime [16]. Finally, for larger fields (over 35 Oe) the only pinning events have quite a large resistance (ΔR>0.32 Ω), which indicates that only very wide and stretched DWs have a chance of being pinned at such a large magnetic field, in concordance with the DW being in a turbulent regime. The fact that the probability of pinning follows the propagation regimes of the DW, indicates that the pinning is intrinsic to the DW motion on magnetic nanostripes and therefore, quite possibly, unavoidable in real (not simulated) structures expect for very low fields, as it has been shown.

It is left to find out the influence of the Oersted field created by the injection pulse in these results. Although the in-plane Oersted field from the current pulse is negligible further than 500nm away from the current line, the perpendicular to plane field reaches considerable values along the entire length of the magnetic stripe. For the current density of 1 V pulse ($1.45 \cdot 10^{8}$ Acm^{-2}), the perpendicular to plane field is about 400 Oe by the edge of the current line, ~40 Oe 2µm away and ~20 Oe 4µm away from the current line [18]. Therefore, this field is not negligible and its influence has to be evaluated. Figure 6.14.4.a shows a map with the resistance of the pinning events for a 25ns-2V injection pulse. As it can be seen the TWs are absent from the pinning events for fields larger than 3 Oe. The pinning probability versus the applied magnetic field for a 25 ns pulse and several pulse amplitudes is shown in figure 4b. In the 10 to 30 Oe field range, at low pulse amplitudes the probability plateaus over 0.2 (like in the results shown in figure 6.14.3.a) while for higher pulse amplitudes, it gradually decreases after 10 Oe. Interestingly, figure 4c also shows that whilst the probability of pinning a VW is not affected by the pulse amplitude, the probability of pinning a TW drops quickly to zero as the pulse amplitude is increased.

It has been shown using micromagnetic simulations that a perpendicular to plane magnetic field can stabilize the TW structure and even suppress the Walker breakdown [19]. In these experiments, at low pulse amplitudes (i.e. small field perpendicular to plane) and intermediate fields (10 to 35Oe), the probability of pinning is the same for both types of DW for any pulse length (figure 6.14.4.d), although the TW disappears from the pinning events as the amplitude is increased (figure 6.14.4.c). As the TW is present in section AB of the nanostripe for all pulse amplitudes (see figures 6.14.2c-e), the perpendicular to plane field from the injection pulse might be enhancing the transmission probability for the TW. This was also shown in Ref. 9, where the simulations showed that on a finite-length stripe, the perpendicular to plane field from the current line, promotes the TW after nucleation. It is interesting to note that in the precessional mode the DW is in the vortex configuration for longer periods of time than in the transversal configuration (although the velocity is larger while being transversal) but their pinning probabilities are the same (figure 6.14.4.d).

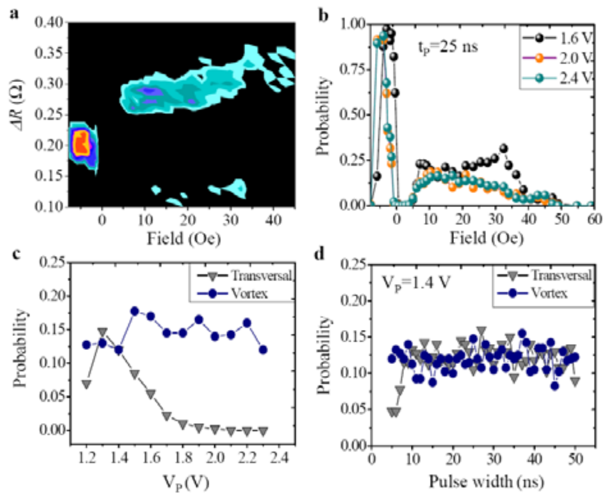

Figure 6.14.4. *Resistance map showing the pinning events for a 25ns-2V injection pulse, versus the applied field (a) Probability of pinning for a 25ns injection pulse and different amplitudes (b) Probability of pinning for the different types of DW versus the amplitude (c) and pulse length (d) at a fixed field of 12.5 Oe.*

The perpendicular to plane field from the current pulse could also affect the DW motion in the low field range, when the pinning probability is zero. The velocity of a DW in this type of nanostripes at low fields has been measured many times by different groups and it should be smaller than 100 m/s. In this case, for pulses shorter than 25 ns (and very low fields) the DW should still be travelling through the nanostripe when the pulse finishes. Therefore, the Oersted field from the injection pulse may trigger the initial movement of the DW but cannot justify its perfect transmission probability at very low fields, which must be a consequence of the rigid structure of the DW when moving at very small velocity (low field regime).

This work shows that the stochastic pinning of a DW in magnetic nanostripes follows different field regimes that match well the propagation modes of the DW. This stochastic behavior of the DW can be suppressed for very low fields, where the structure to the DW should not suffer any viscous transformations or deformations. In this regime, the DW can be transmitted reliably without ever pinning. At very low fields, the velocity and the kinetic energy of the DW are very small and it might seem counterintuitive to find that it is precisely in this regime where the DW never gets pinned along the stripe. In fact, other results have shown that the depinning of a DW from a notch is more efficient when the DW is moving (kinetic field depinning smaller than static field depinning) [20,21]. These results are measured for strong pinning potentials (notch or anti-notch) while the results reported here are measured in the weak pinning regime.

In this weak pinning regime, the probability of pinning increases for higher fields (higher speed), quite likely due to the relation between the phase of the DW and the local potential [4]. In this low pinning regime, as soon as the external field provides enough energy for the DW to achieve shape transformations or deformations, there is an increasing chance for the DW to adapt to the local micro-structure and to minimize its energy by getting pinned. Note also that the pinning probability increases gradually from very low fields (~3 Oe) until it plateaus around 10 Oe (approximately the Walker breakdown field in permalloy wires of these dimensions). This means that, even for fields considerably smaller than the Walker breakdown (the beginning of the precessional regime) there is a non-zero probability of finding outlying events where the DW travels in the precessional mode even for fields well within the translational mode.

The enhanced DW pinning at high fields has been observed before [4,7]. The results from Ref 4 and 5 indicated also that the probability of pinning at low fields could be quite low. The results reported here in contrast, show distinctively that this probability of pinning follows the same modes than the DW motion and provide evidence that it can be completely suppressed at very low fields. This work highlights the necessity of designing the racetrack devices with materials and geometries that can delay the Walker breakdown to higher fields [22,23]. Additionally, a perpendicular to plane field seems to enhance the transmission probability. This could be implemented easily on a Race-Track device by depositing a hard magnetic material as a buffer layer with the magnetization perpendicular to plane.

References

[1] Allwood, D. A. et al. *Science* **309**, 1688 (2005).
[2] Parkin, S.S.P., Hayashi, M .& Thomas, L . *Science* **320**, 190 (2008).
[3] Koyama, T., et al. *Nature Mat*. **10**, 194 (2011).
[4] Jiang X. et al. *Nat. Commun*. **1**:25 doi: 10.1038/ ncomms1024 (2010).
[5] Meier, G. et al. *Phys. Rev. Lett*. **98**, 187202 (2007).
[6] J. Akerman, M. Muñoz, M. Maicas, & J. L. Prieto, *Phys. Rev. B* **82**, 064426 (2010).
[7] Tanigawa, H. et al. *Phys. Rev. Lett*. **101**, 207203 (2008).
[8] Jiang, X., Thomas, L., Moriya, R. & Parkin, S.S.P., *Nano Lett*.**11**, 96 (2011).
[9] Prieto, J.L., Muñoz, M. & Martínez, E., *Phys. Rev. B*. **83**, 104425 (2011).
[10] Hayashi, et al.., *Phys. Rev. Lett*. **97**, 207205 (2006).
[11] Chanthbouala A. et al. *Nature Physics*, **7** doi: 10.1038/nphys1968 (2011).
[12] Hayashi, et al.., *Phys. Rev. Lett*. **96**, 197207 (2006).
[13] Yang, J., Nistor, C., Beach, G.S.D., and Erskine, J.L., *Phys. Rev. B* **77**, 014413 (2008).
[14] Beach, G.S.D., et al.., *Phys. Rev. Lett*. **97**, 057203 (2006).
[15] Hayashi, et al., *Nature Phys*. **3**, 21.25, doi: 10.1038/nphys464 (2007).

[16] Lee, J.-Y., et al., *Phys. Rev. B* **76**, 184408 (2007).
[17] Kim, S.-K, et. al., *Appl. Phys. Lett*. **93**, 052503 (2008).
[18] Jackson, J. D., Classical Electrodynamics, (John Wiley & Sons, New York, 1998).
[19] Lee, J.-Y, Lee, K.-S & Kim, S.-K, *Appl. Phys. Lett*. **91**, 122513 (2007).
[20] Ahn, S.- M., et al.. *Appl. Phys. Lett*. **95**, 152503, (2009).
[21] Lewis, E.R., et al.. *Appl. Phys. Lett*. **98**, 042502 (2011).
[22] Lewis, E.R. et al. *Nature Mat.* doi: 10.1038/NMAT2857 (2010).
[23] Nakatani,Y., Thiaville, A. & Miltat,*J. Nature Mater*. **2**, 521 (2003).

6.15 Direct growth of compact InGaN layers on Si [15]

Richard Notzel and Enrique Calleja

The growth of compact InGaN layers with high In composition directly on Si is the base for the most flexible heterostructures and novel devices and for the ultimate goal of integration with Si technology. This however, was considered to be quite hard due to the nucleation stage resulting in nanostructured layers leading to nonuniform, selective In incorporation. This work reports on two routes developed at ISOM to overcome this problem: i) by enhancing the selectivity to macroscopic length scales, and ii) by drastically suppressing it kinetically [1][2].

I. Direct growth of planar InGaN layers on Si: Enhancing selective In incorporation

Novel InGaN based opto-electronic devices and their integration with Si technology demand the direct growth of compact InGaN layers on Si. This, however, so far led to nanostructured, nonuniform layers. Therefore, always AlN, GaN, or combined buffer layers have been employed. This, however, is not the solution as they form an energy barrier, electrically isolating the InGaN layer from the Si substrate and, hence, making novel device designs such as InGaN/Si tandem solar cells [3] impossible. The origin of the nanostructured and nonuniform InGaN layers lies in the early stage of growth involving nucleation of three-dimensional islands, coalescence, and layer growth. This inevitably leads to varying In composition and roughness on the nanoscale due to selective incorporation of In on the initially non-planar surface which have not yet been seen to recover during growth.

It is found that it is possible to establish growth conditions that enforce this selectivity to larger length scales for forming planar high-In-composition InGaN layers with the required lateral dimensions on the micrometer scale which contain trenches and holes associated with almost pure GaN, which we will proof in the following. Such growth conditions were identified for the relatively low growth temperature of 450°C and close to stoichiometry in plasma assisted molecular beam epitaxy (PA MBE) on Si (111) substrates. Before growth of the InGaN layer the substrate was heated up to 850^{o}C and nitridized for 5 min which is a well established procedure for the growth of pure GaN on Si. Figure 6.15.1 shows a top-view scanning electron microscopy (SEM) image of such a layer containing micrometer sized planar areas together with trenches and holes. The planar regions are remarkably smooth with root-mean-square roughness of 1.7 nm measured by atomic force microscopy (AFM).

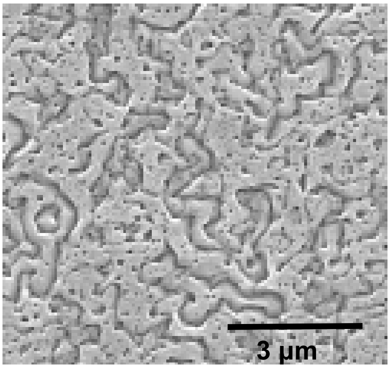

***Figure 6.15.1**. Top-view SEM image of the InGaN layer on Si (111).*

The presence of macroscopic regions of high-In-composition InGaN together with regions of almost pure GaN is confirmed by high-resolution X-ray diffraction (XRD) showing two distinct reflections corresponding to InGaN with In composition around 40% and to pure GaN and InGaN with In composition < 15%. Already here one can likely state that the high-In-composition regions are the macroscopically extended planar layers, while the GaN plus low-In-composition regions are associated with the trenches and holes, exposing slow-growth planes that inhibit the incorporation of In. This is confirmed by cross-sectional SEM and cathodoluminescence (CL) imaging.

Figure 6.15.2.a shows the cross-sectional SEM image of the InGaN layer. The macroscopically extended planar layers exhibit a uniform bright material contrast, typical for InGaN with high In

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composition. Underneath the trenches or holes, dark stripes are seen. These dark stripes are associated with pure GaN and low-In-composition InGaN, confirming the selective incorporation of In mostly in the planar areas, leaving regions of GaN and low-In-composition InGaN underneath the trenches and holes when the growth proceeds. This is most directly proven by the CL image shown in figure 6.15.2.b recorded at room temperature at the peak emission wavelength of GaN of 365 nm and laid over the topographic SEM image. The bright, round-shaped contrast in the CL image due to the emission of GaN is located solely in the hole, which appears as dark contrast in the SEM image. No emission at room temperature is obtained from the high-In-composition InGaN. However, together with the results from the XRD measurements, the extended planar layers are now unambigously associated with high-In-composition InGaN.

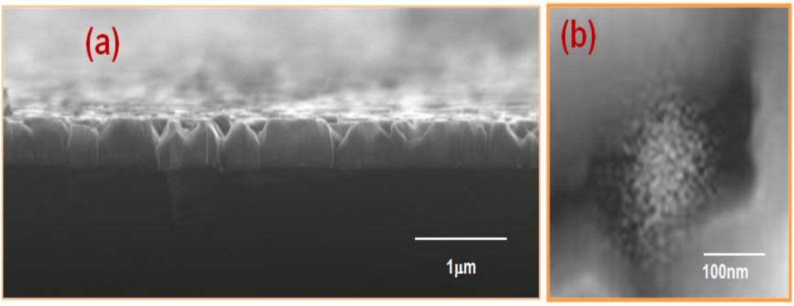

Figure 6.15.2. *(a) Cross-sectional SEM image of the InGaN layer on Si (111). (b) CL image recorded at room temperature at the GaN peak emission wavelength of 365 nm, laid over the topographic SEM image.*

Optical emission from the high-In-composition InGaN layer is observed at low temperature. Figure 6.15.3.a shows the photoluminescence (PL) spectrum taken at 12 K. The two peaks at the short wavelengths of 358 and 383 nm are due to GaN and low-In-composition InGaN. The emission centered at the long wavelength of 794 nm stems from the high-In-composition InGaN. The PL peak energy corresponds to an In composition of 41%, in accordance with the XRD results.

The InGaN layers are grown on p-type Si substrates, and figure 6.15.3.b shows the I-V curve measured with bottom and top Al contacts. The behavior is perfectly ohmic. It should be noted that the InGaN layer is highly n-type conductive, which is commonly observed and related to native defects such as nitrogen vacancies. This proves that an ohmic contact is formed between the p-Si substrate and n-InGaN layer, confirming the theoretical prediction [3] and consolidating the foundation for advanced device applications.

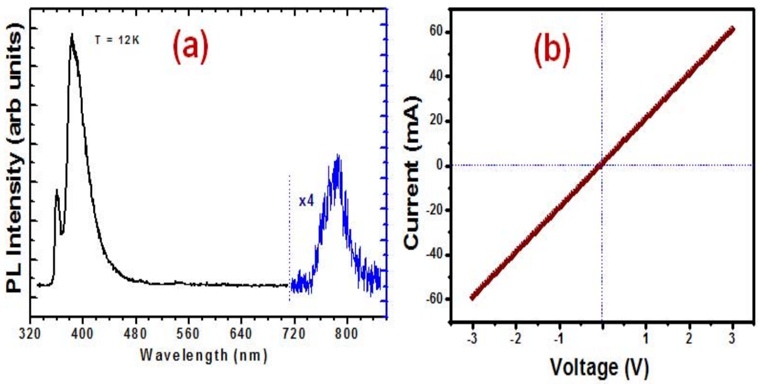

Figure 6.15.3. *(a) PL spectrum taken at 12 K of the InGaN layer. (b) Back-to-front I-V curve for the n- InGaN layer on the p-Si substrate.*

II. Direct growth of uniform InGaN layers on Si: Suppressing selective In incorporation

To the question whether it is possible to form uniform InGaN layers across the entire substrate, indeed this is possible when the selective In incorporation is kinetically most strongly suppressed at drastically reduced growth temperature around 320°C, which is about 100ºC lower than in the previous experiment. However, this is achieved at the cost of an undulated surface.

For these growth conditions the In composition can be most easily adjusted by the Ga/In flux ratio without qualitative change of the surface morphology as shown by the top-view SEM images of InGaN layers with In compositions of (a) 10, (b) 25, and (c) 33% (figure 6.15.4), as determined by XRD, showing single peaks for the InGaN layers, indicating a uniform composition. Moreover, PL is observed up to room temperature for all layers, depicted in figure 6.15.5, revealing high optical quality. Emission is provided in the blue, green, and red spectral regions, which is required for the realization of white light sources.

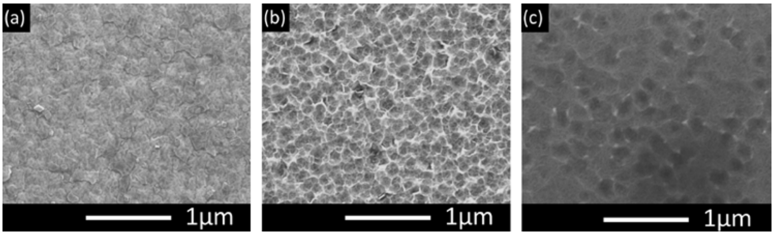

***Figure 6.15.4**. Top-view SEM images of the InGaN layers on Si (111) with (a) 10, (b) 25, and (c) 33% In composition*

As the sample with 25% In composition exhibits the best PL properties with emission in the technologically important yellow-green spectral region it is chosen for in-depth transmission electron microscopy (TEM) investigations. Figure 6.15.6.a presents a high angle annular dark field (HAADF) image for a cross-sectional view. There are no pronounced fluctuations in the image intensity, i.e., no compositional variations are detected. The uniform In and Ga compositions are also confirmed by energy dispersive X-ray (EDX) measurements revealing that the In composition varies less than 2%. These results confirm the suppression of selective In incorporation and the formation of a chemically homogeneous InGaN layer on Si at such low growth temperatures.

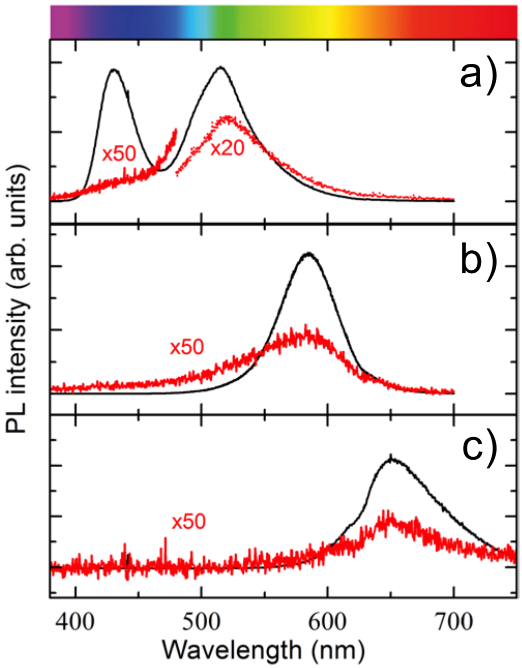

***Figure 6.15.5**. PL spectra of InGaN layers on Si(111) with (a) 10, (b) 25 and (c)33 % of In composition taken at 8K (black) and RT (red) lines).*

The high-resolution TEM (HRTEM) image depicted in figure 6.15.6.b indicates sharp $Si/SiN_x/InGaN$ interfaces and a continuous and homogeneous SiN_x interlayer, formed due to nitridation of the Si surface. Right above this SiN_x interlayer, straight lattice planes are observed which indicate that perfect heteroepitaxy between InGaN and Si has taken place.

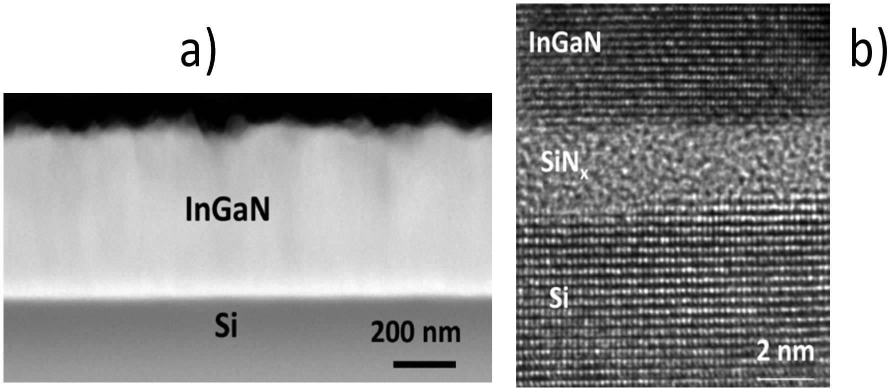

Figure 6.15.6*. (a) HAADF and (b) HRTEM images of the InGaN layer with 25% In composition on Si.*

References

[1] P. Kumar, P. E. D. Soto Rodríguez, V.J. Gómez, N. H. Alvi, E.Calleja, and R. Nötzel, *Appl. Phys. Express* **6**, 035501 (2013).

[2] P. Aseev, P.E.D. Soto Rodriguez, P. Kumar1, V.J. Gómez, N.H. Alvi1, J.M. Mánuel, F.M. Morales, J.J. Jiménez, R. García, E. Calleja, R. Nötze1, *Appl. Phys. Express* **6**, 115503 (2013).

[3] L. Hsu, W. Walukiewicz, *J. Appl. Phys*. **104**, 024507 (2008).

6.16 InN/InGaN quantum dots for intermediate band solar cells and biosensors [16]

Richard Notzel and Enrique Calleja

This work reports on InN quantum dots (QDs) grown on high-In-composition InGaN with the aim to push the operation of III-N semiconductors into the near-infrared. Specifically, high-quality InGaN layers have been obtained with bandgap energy, together with that of the InN QDs tuned to the best match of absorption to the solar spectrum. When the QDs were biochemically functionalized for the electrochemical detection of glucose, the fabricated biosensor revealed exceptionally high sensitivity and fast response time [1][2].

I. InN/InGaN QDs for intermediate band solar cells

The strong motivation to employ the InGaN material system for solar cells comes from its intrinsic properties: wide tunability of the bandgap over the whole solar spectrum, high near band edge absorption, high carrier mobility, and superior radiation resistance. Establishing the optimum bandgap for intermediate band solar cells [3] requires InGaN layers with In composition around 50%. This is the most critical In composition for the growth of high-quality InGaN layers due to the strong tendency of phase separation and the low growth temperatures required to avoid InN decomposition and In desorption. And indeed a large effort has been devoted at ISOM to realize such InGaN layers of high quality. The growth was performed by radio-frequency (RF) plasma assisted molecular beam epitaxy (PA-MBE) on (0001) GaN/sapphire substrates and finally optimum growth conditions have been identified at reduced growth temperature and elevated active N flux. Figures 6.16.1.a-f show the atomic force microscopy (AFM) images of a series of layers visualizing this result. For the smoothest layer with an In composition of 54% and 80 nm thickness, shown in figure 6.16.1.a, phase separation is absent, as confirmed by high-resolution X-ray diffraction (XRD).

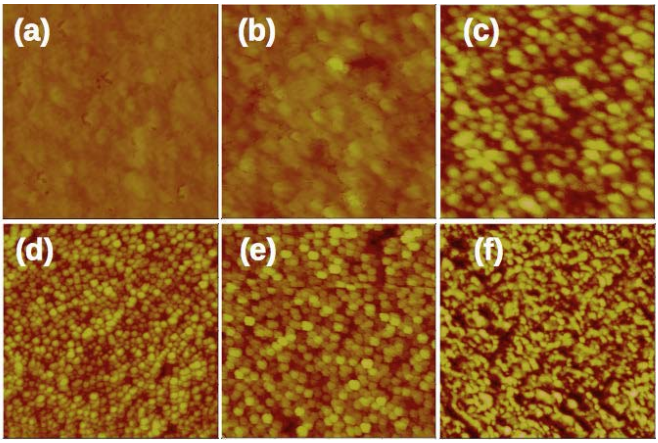

Figure 6.16.1. *AFM images of the $In_{54}Ga_{46}N$ layers grown at (a,d) 460, (b,e) 500, and (c,f) 540ºC for (a-c) RF power of N1 = 230 and (d-f) RF power of N2 = 200 W. The scan fields are 1 µm × 1 µm and the full height contrast is 20 nm for all images.*

On such optimized InGaN layers InN QDs were grown with InN coverage of 1 and 2 monolayers. The corresponding AFM images are shown in figure 6.16.2 where the QDs appear as distinct rounded features together with large clusters on the otherwise gently undulated InGaN surface.

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The QD diameter of 20 – 30 nm and the QD height of 2 – 3 nm do not change significantly with InN coverage while the QD density increases by almost one order of magnitude from 2.2 × 10^9 cm^{-2} to 1.5 × 10^{10} cm^{-2} when the InN coverage is increased from 1 to 2 monolayers. When the In coverage is further increased, no QD-like structures are observed. This indicates lateral closing of the QD layer back to an undulated film and, hence, a very narrow InN coverage window for forming well-defined QDs.

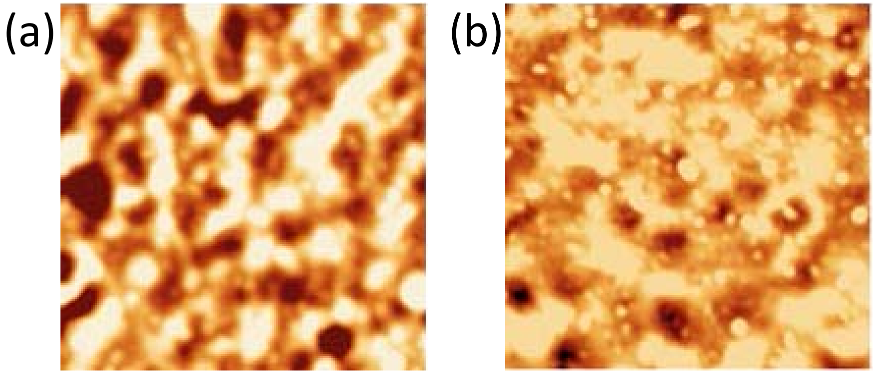


Figure 6.16.2. *AFM images of the (a) 1 and (b) 2 monolayer InN QDs grown on the optimized $In_{54}Ga_{46}N$ layers. The scan fields are 500 nm × 500 nm and the full height contrast is 5 nm for all images.*

Both, the 1 and 2 monolayers InN QD samples exhibit clear photoluminescence (PL) emission. The temperature dependent PL spectra of the 1 monolayer InN QD sample are shown in figure 6.16.3.a together with the PL spectrum of the bare InGaN layer the Inset. The superimposed Fabry-Pérot fringes are caused by the 3.3 µm thick GaN layer. Clearly, the PL band centered at the higher energy of 1.4 eV stems from the InGaN layer and the band centered at the lower energy of 1.1 eV stems from the InN QDs. In the temperature dependent PL spectra, the intensity of the PL of the InGaN layer decreases with temperature increase while the QD PL intensity first increases for temperatures up to 40 K before it starts to decrease. This is a typical behavior for QDs due to thermally activated transfer of carriers from the InGaN layer to the QDs before the PL is quenched and, in fact, indicates good carrier transport through the InGaN layer, needed for solar cells. Most important is, however, that the PL energies indicate the optimum bandgap energies of the InGaN layer and InN QDs for intermediate band solar cells.

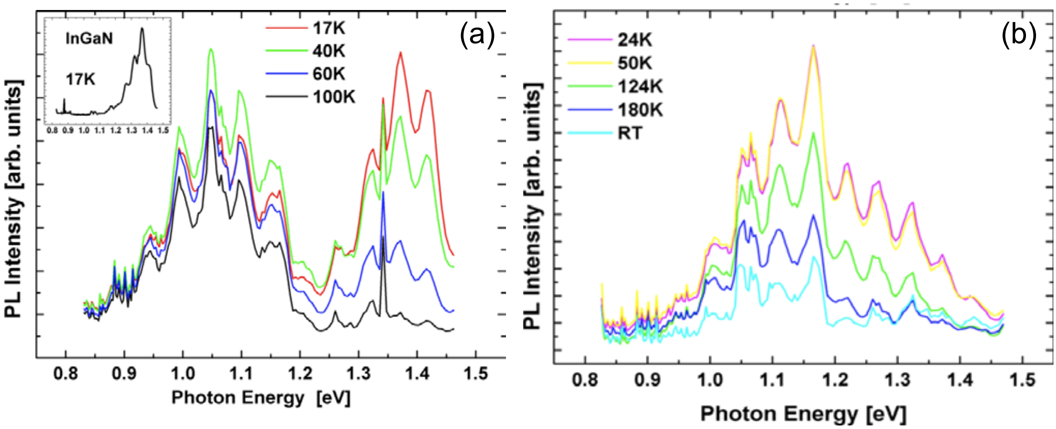


Figure 6.16.3. *(a) Temperature dependent PL spectra of the 1 monolayer InN QD sample. Inset: PL spectrum of the bare InGaN layer taken at 17 K. (b) Temperature dependent PL spectra of the 2 monolayers InN QD sample.*

Figure 6.16.3.b shows the temperature dependent PL spectra of the 2 monolayers InN QD sample. The PL of the QDs is now much stronger than the PL of the InGaN layer due to the larger QD density and, remarkably, is observed up to room temperature (RT). This is a very important criterium for indicating very high optical quality.

II. Highly sensitive and fast InN/InGaN QDs potentiometric biosensor

Based on these InN/InGaN QDs a highly sensitive and efficient potentiometric glucose biosensor has been developed [2]. The InN QDs were bio-chemically functionalized through physical adsorption of glucose oxidase (GOD). Figure 6.16.4 depicts the schematic illustration of the glucose sensing setup using the working electrode comprised of the functionalized InN QDs against a Ag/AgCl reference electrode. It also illustrates the electrochemical reaction near the biosensing electrode.

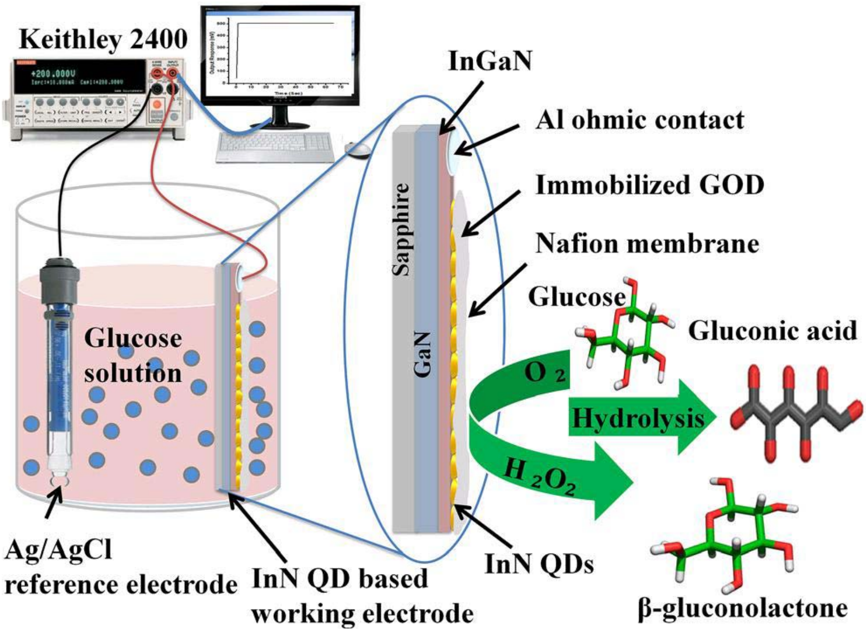


***Figure 6.16.4**. Schematic illustration of the glucose sensing setup using the working electrode comprised of InN QDs coated with GOD against a Ag/AgCl reference electrode, along with the possible electrochemical reaction near the electrode.*

The GOD enzyme-coated InN/InGaN QDs based biosensor exhibits excellent glucose concentration dependent electrochemical response over a wide glucose concentration range. Figure 6.16.5.a depicts the electrochemical cell voltage (EMF) response of the biosensor measured for glucose concentrations from 1×10^{-5} M to 1×10^{-3} M. The EMF is linear versus the logarithmic concentration of glucose increasing from 410 mV for 10 μM to 658 mV for 100 mM and it shows a significantly high slope value, above 80 mV/decade.

The glucose biosensor also delivers fast EMF response as a function of time. A very stable output signal is achieved within 2 seconds, as shown in figure 6.16.5.b, attributed to the planar arrangement of the InN QDs. The time response for the bare InGaN layer, which also has been measured for comparison, is much slower and the maximum EMF is significantly lower and not stable, as shown in figure 5c. This reveals the major contribution of the InN QDs for precise and stable glucose sensing, attributed to the high density of positively charged donor states on the InN surface, as high as 10^{13} cm^{-2}.

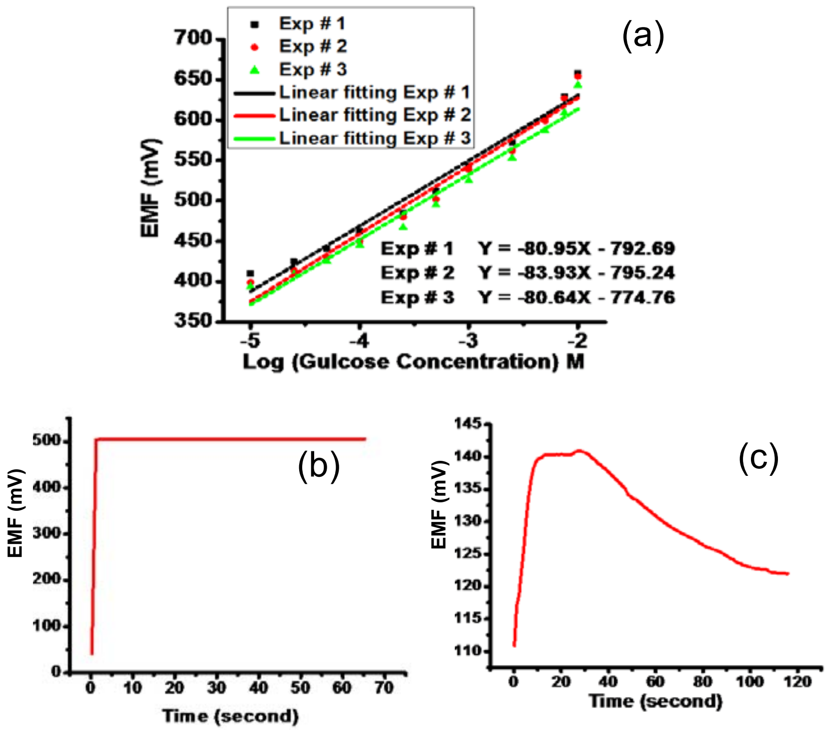


Figure 6.16.5. *(a) EMF as a function of the logarithmic glucose concentration. Exp # 1 – 3 denote three different experiments. EMF as a function of time of the (b) InN-QDs-based and (c) InGaN-layer-based biosensors.*

Moreover, the biosensor shows negligible response to common interferents such as ascorbic acid and uric acid and, important for clinical diagnostics, it shows very good reusability. The EMF did not change in a series of experiments for fourteen days using the same biosensor.

A biosensor for the detection of cholesterol has also been fabricated by immobilization of cholesterol oxidase [4]. It shows similar excellent sensing properties. Finally, bare InN/InGaN QDs have been demonstrated for highly sensitive and fast anion selective potentiometric sensors [5], underlining the wide applicability of these novel QD structures for electrochemical sensing.

References

[1] P.E.D. Soto Rodriguez, V.J. Gómez, P. Kumar, E. Calleja, R. Nötzel, *Appl. Phys. Lett*. **102**, 131909 (2013).

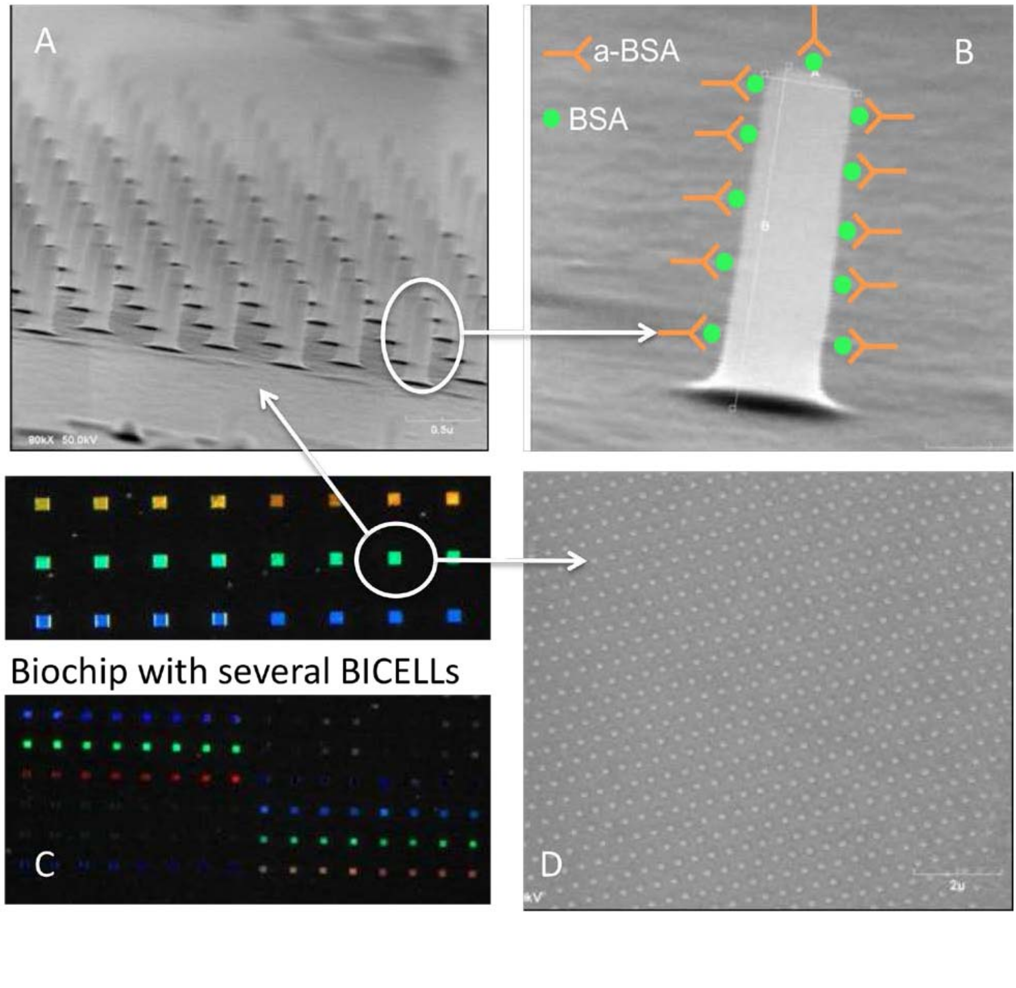
[2] N.H. Alvi, P.E.D. Soto Rodriguez, V.J. Gómez, P. Kumar, G. Amin, O. Nur, M. Willander, R. Nötzel, *Appl. Phys. Lett*. **101**, 153110 (2012).

[3] A. Luque and A. Marti, *Phys. Rev. Lett*. **78**, 50145017 (1997).

[4] N.H. Alvi, V.J. Gómez, P.E.D. Soto Rodriguez, P. Kumar, S. Zaman, M. Willander, R. Nötzel, *Sensors* **13**, 13917 (2013).

[5] N.H. Alvi, P.E.D. Soto Rodriguez, V.J. Gómez, P. Kumar, M. Willander, R. Nötzel, *Appl. Phys. Express* **6**, 115201 (2013).

7 RESEARCH PROJECTS



A) SEM micrograph of a SU8-based BICELL, B) SEM micrograph of one single nano-pillar and a schematic representation of BSA immobilization and aBSA recognition. C), Optical image of a biochip with an array of BICELLs, D) SU8-BICELL top-view SEM micrograph.

7.1 International Public Funding

Europe:

"High quality Material and intrinsic Properties of InN and indium rich Nitride Alloys (The Rainbow ITN)"
European Commission. Reference: 213238- PITN-GA-2008-213238 (2008-2012)
Principal Investigator: Miguel Ángel Sánchez-García

"Novel Gain Materials and Devices Based on III-V-N Compounds – COST MP0805"
European Commission. Reference: COST MP0805 (2008-2012)
Principal Investigator: José María Ulloa

"Directed Assembly of Polymeric Materials Nanofabrication (DAPOMAN)"
European Commission. Reference: PIIF-GA-2009-236797 (2009-2010)
Principal Investigator: Manuel Laso

"Smart Nanostructured Semiconductors for Energy-Saving Light Solutions (SMASH)"
European Comission. Reference: Nº 228999, FPT-NMP-2008-LARGE 2 (2009-2011)
Principal Investigator: Enrique Calleja

"Substrate nanopatterning by e-beam lithography to growth ordered arrays of III-Nitride nanodetectors: application to IR detectors, emitters, and new Solar Cells" (Action Marie Curie)
European Comission. Reference: PIEF-GA-2009-253085 (2009-2012)
Principal Investigator: Enrique Calleja

"3D GaN for High Efficiency Solid State Lighting (GECCO)"
European Comission. Reference: Nº 280694, FP7-NMP-2011-SMALL-5, NMP-2011-2.2-3 Materials for Solid State Lighting (2012-2014)
Principal Investigator: Enrique Calleja

USA:

"MBE regrowth of a laterally-biased double quantum well tunable detector"
European Office of Aerospace Research and Development. Reference: FA8655-09-1-3047 (2009-2010)
Principal Investigator: Álvaro de Guzmán Fernández

"Laterally biased Quantum IR detectors"
European Office of Aerospace Research and Development. Reference: Award FA8655-12-1-3006 (2011-2013)
Principal Investigator: Álvaro de Guzmán Fernández

JAPAN (OTHER INTERNATIONAL COOPERATION PROJECTS):

"ZnMGO-Based nanocolumnar and core-shell LEDs with high power efficiences"

Japan Science and Technology Agency. Ministerio de Ciencia e Innovación. Reference: PIB2010JP-00279 (2010-2013)

University of Shizuoka (Japan) - IP ISOM: Adrián Hierro

Integrated Actions (travel and stage funding):

"High frequency nanoresonators by MEMS technologies"

HISPANO-ALEMANA (Fraunhofer Institute for Applied Solid State Physics IAF), Reference: DE2009-0015 (2010-2012)

Principal Investigator: Fernando Calle, IP Fraunhofer IAF: Volker Cimalla

7.2 National and Regional Public Funding

''Tecnologías de Información Basadas en Optica Cuántica''
Programa Consolider-Ingenio, Reference: CSD2006-19 (2006-2011)
Principal Investigator: Jürgen Eschner. Fundación Privada Instituto de Ciencias Fotónicas
Investigador por ISOM- UPM: Enrique Calleja

"I+D de Micro y Nanosistemas basados en Nitruros III-V para comunicaciones y sensores MINANI"
Ministerio de Educación y Ciencia, Reference: TEC-2007-67065/MIC (2007-2010)
Principal Investigator: Fernando Calle

''Obtención y caracterización de nanoestructuras magnéticas obtenidas por pulverización catódica y nanolitografía por
haz de electrones''
Ministerio de Educación y Ciencia, Reference: MAT2007-65965-C02-01 (2007-2010)
Principal Investigator: Marco Maicas

''Programa de investigación en ingeniería biomédica. MADRID, IB-CM''
Comunidad de Madrid- Univ. Politécnica Madrid, Reference: S-SAL ORDEN 6892/2006 (2007-2011)
Principal Investigator: D. Francisco del Pozo/ ISOM-UPM: Claudio Aroca

"Ayudas financieras para la mejora de las infraestructuras científicas y tecnológicas singulares y para el acceso a las mismas"
Ministerio de Educación y Ciencia, Reference: ICTS-2008-29 (2008)
Principal Investigator: Enrique Calleja

''Síntesis y caracterización de nanopartículas magnéticas funcionarizadas y estables en medios biológicos, NANOMAG''
Ministerio de Sanidad y Consumo, Reference: CIBER-BBN (2008-2009)
Coordinator: D. Francisco del Pozo Guerrero/ ISOM-UPM: Claudio Aroca

''Desarrollo de Micro y Nanocavidades incluyendo regiones activas de Puntos Cuánticos de Nitruros-III: Aplicaciones a emisores de luz en azul y UV (QUADONIC)''
Ministerio de Educación y Ciencia, Reference: MAT2008-04815 (2008-2011)
Principal Investigator: Enrique Calleja

''Desarrollo de estructuras nano-opto-fluídicas (BIOPSIA-2)''
Ministerio de Educación y Ciencia, Reference: TEC2008-06574-C03-03/TEC (2008-2011)
Principal Investigator: Carlos Angulo

''Nano- y microdispositivos basados en ZnO para la detección de H2 y UV (THINKOXIDE)''
Ministerio de Ciencia e Innovación, Reference: TEC2008-04718 (2008-2011)
Principal Investigator: Adrián Hierro

"Ayudas financieras para la mejora de las infraestructuras científicas y tecnológicas singulares y para el acceso a las mismas"
Ministerio de Educación y Ciencia, Reference: ICTS-2009-30 (2009)
Principal Investigator: Enrique Calleja

"Estudio de la transferencia de espín en paredes y nanosistemas magnéticos. Aplicación a sensores y memorias magnéticas alternativas (MAGWALLMEM)"

Ministerio de Ciencia e Innovación. Reference: MAT2008-02770/NAN (2009-2011)

Princial Investigator: José Luis Prieto

"Microsistemas de control térmico para aplicaciones industriales"

Comunidad de Madrid. Reference: P2009/DPI-1572 (T-MEMS) (2010-2011)

Principal Investigator: Gonzalo Fuentes

"Amplificadores de envolvente de banda ancha para etapas EER/ET y fabricación de dispositivos de nitruros de Galio (GaN)"

Ministerio de Ciencia e Innovación, Reference: TEC2009-14307-C02-01 (2010-2012)

Principal Investigator: Oscar García, IP ISOM-UPM: Fernando Calle

"Nanodispositivos eficientes de luz clásica y cuántica"

Comunidad de Madrid. Reference: P2009/ESP-1503 (2010-2013)

Principal Investigator: Enrique Calleja

"High frequency Resonators on AlN/Diamond structures, ReADi"

Ministerio de Ciencia e Innovación. Reference: TEC2010-19511 (2010-2013)

Principal Investigator: Fernando Calle

"Advanced Wide Band Gap Semiconductor Devices for Rational Use of Energy, RUE"

Ministerio de Ciencia e Innovación. Consolider. Reference CSD2009-00046 (2009-2014)

Principal Investigator ISOM-UPM: Fernando Calle. Coordinator: J. Millán (CNM-CSIC)

"Hierarchical modelling of biosensors"

Ministerio de Ciencia e Innovación. Reference: MAT2010-15482 (2010-2015)

Principal Investigator: Nikolaos Karayiannis

"Dispositivos nanofotónicos para comunicaciones ópticas"

Comunidad de Madrid-UPM. Ayudas cofinaciadas para jóvenes doctores investigadores. Ref: QM100920B071 (2011-2012)

Principal Investigator: José María Ulloa

"Fabricación de filtros de ondas superficiales"

Comunidad de Madrid-UPM. Ayudas cofinaciadas para jóvenes doctores investigadores. Ref: QM100920B070 (2011-2012)

Principal Investigator: Gonzalo Fuentes

"Escritura directa por haz de electrones en polímeros de impronta molecular para el desarrollo de nanobiosensores fotónicos (EMIP)"

Ministerio de Ciencia e Innovación. Reference: TEC2010-10804-E (subprogram TEC) (2011-2012)

Principal Investigator: Carlos Angulo Barrios

"Emerging oxide-based UV Photonics"

Ministerio de Ciencia e Innovación. Reference: TEC2011-28076-C02-01. Plan Nacional 2008-2011 (2011-2014)

Universidad de Valencia – ISOM UPM: Adrián Hierro

"Nanomateriales magnéticos y sus aplicaciones en sistemas de interacción a distancia"

Ministerio de Ciencia e Innovación. Reference MAT2011-28751-C02-01. Plan Nacional 2008-2011 (2011-2014)

Principal Investigator: Claudio Aroca

"Study of the domain wall dynamics along stripes and magnetization oscillations in multilayer nanostructures driven by spin-polarized currents"

Ministerio de Educación y Ciencia, Reference: MAT2011-28532-C03-03. Plan Nacional 2008-2011 (2011-2014)

Universidad de Salamanca – ISOM UPM: José Luis Prieto

''Estudio de titanomagnetitas. Microsusceptómetro para exploración planetaria''

Ministerio de Economía y Competitividad. Reference: PRI-PIBUS-2011-1182 (2011-2014)

Universidad Carnegie Mellon (USA) - I.N.T.A/ISOM-UPM: Marco Maicas

''Una iniciativa para caracterizar fljos multifósicos de biofluídos y cristales líquidos''

Ministerio de Ciencia e Innovación. Reference: MAT2011-24834. Plan Nacional 2008-2011 (2011-2014)

Principal Investigator: Katerina Foteinopoulou

"Células solares de InGaN mejoradas con plasmones superficiales y fabricadas por MBE sobre sustratos de silicio y capas de GaN”

Ministerio de Ciencia e Innovación. Reference MAT2011-26703. Plan Nacional 2008-2011 (2011-2014)

Principal Investigator: Miguel Ángel Sánchez-García

"Photonic chemical microsensors based on GaN LEDs for safety applications using smartphones''

Ministerio de Economía y Competitividad. Reference: MINECO: CTQ2012-37573-C02-01 and Reference UE Marie-Curie: FP7-PEOPLE-2013-ITN ("SAMOSS") (2012)

Principal Investigator: Elías Muñoz (ISOM) and Guillermo Orellana (UCM)

''Programa integral de Ingeniería Biomédica para el desarrollo de técnicas diagnósticas y terapéuticas en enfermedades neurológicas. NEUROTEC ''

Comunidad de Madrid. Reference: S2010/BMD-2460 (2012-2014)

Principal Investigator ISOM-UPM: Claudio Aroca

''Convertidores de alta velocidad de conmutación multinivel y multifase para aplicaciones espaciales''

Ministerio de Economía y Competitividad. Reference: TEC2012-38247-C02-01 (2013-2015)

Principal Investigator ISOM-UPM: Fernando Calle

''Biochip kits basados en celdas biofotónicas y plataformas avanzadas de interrogación óptica''

Ministerio de Economía y Competitividad. Reference: MINECO. Plan Nacional (TEC2012-31145) (2013-2016)

Universidad Politécnica de Valencia- IP ISOM: Carlos Angulo

''Células solares de heterounión InGaN y alta eficiencia crecidas por MBE''

Ministerio de Ciencia e Innovación. PLE2009-0023 (2009-2012)

Principal Investigator: Enrique Calleja

''Nanodispositivos eficientes de luz clásica y cuántica (Q&CLight)''
Comunidad de Madrid – Univ. Politécnica Madrid. Ref: S-0505/ESP-0200 (2009-2014)
Principal Investigator: Luis Viña / Enrique Calleja (ISOM-UPM)

''Microsistemas de control térmico en aplicaciones industriales (T-MEMS)''
Comunidad de Madrid – Univ. Politécnica Madrid. Ref: S-2009/DPI-1572 (2009-2014)
Principal Investigator: Ángel Velázquez/ Gonzalo Fuentes (ISOM-UPM)

''Advanced Wide Band Gap Semiconductor Devices for Rational Use of Energy", RUE (Dispositivos Avanzados de Gap Ancho para el uso racional de la energía)".
Ministerio de Ciencia e Innovación: CSD2009-00046 (2009-2014)
Principal Investigator: Fernando Calle

"Multiphase-Oriented, BIofluid and LIquid crystalline Flows Endeavor" (MOBILIFE)
Subprograma de Proyectos de Investigacion Fundamental no Orientada;
MAT2011-24834 (2012-2014)
Principal Investigator: Katerina Foteinopoulou

7.3 Funding from Companies and Institutions

"Estudio del comportamiento de los campos magnéticos de la subestación eléctrica de Sainz de Baranda"
Metro Madrid-UPM. Reference: P090920B 466 (2010)
Principal Investigator: Marco Maicas

"Nuevo sistema de identificación integral y en tiempo real de vehículos"
Entidad: SIMAVE S.A-UPM. Código: P11 0920B 469 (2010-2012)
Principal Investigator: Claudio Aroca

''Contrato empresa HEMTs''
Entidad: (Confidential). Reference: P110920B324 (2011-2012)
Principal Investigator: Fernando Calle

''Fabricación de hilos ferromagnéticos mediante litografía y sputtering''
Instituto de Fisica Aplicada (CSIC)-ISOM (UPM). Reference: P110920B136 (2011-2012)
Principal Investigator: José Luis Prieto

''Realización de Antenas Ópticas"'
Instituto de Fisica Aplicada (CSIC)-ISOM (UPM). Reference: P110920B385 (2011-2012)
Principal Investigator: José Luis Prieto

"Contrato Programa dentro del convenio entre FUNDACION BBVA-UPM''
FUNDACION BBVA-UPM. Reference: P090020222B (2011-2014)
Principal Investigator: Richard Noetzel

"Fase preparatoria de solicitud al Programa Inspire REPSOL-UPM. Sistemas de Almacenamiento de Energía basado en Grafeno para Vehículos Eléctricos"
REPSOL-UPM: Reference: P120020070 (2012-2012)
Principal Investigator: Fernando Calle

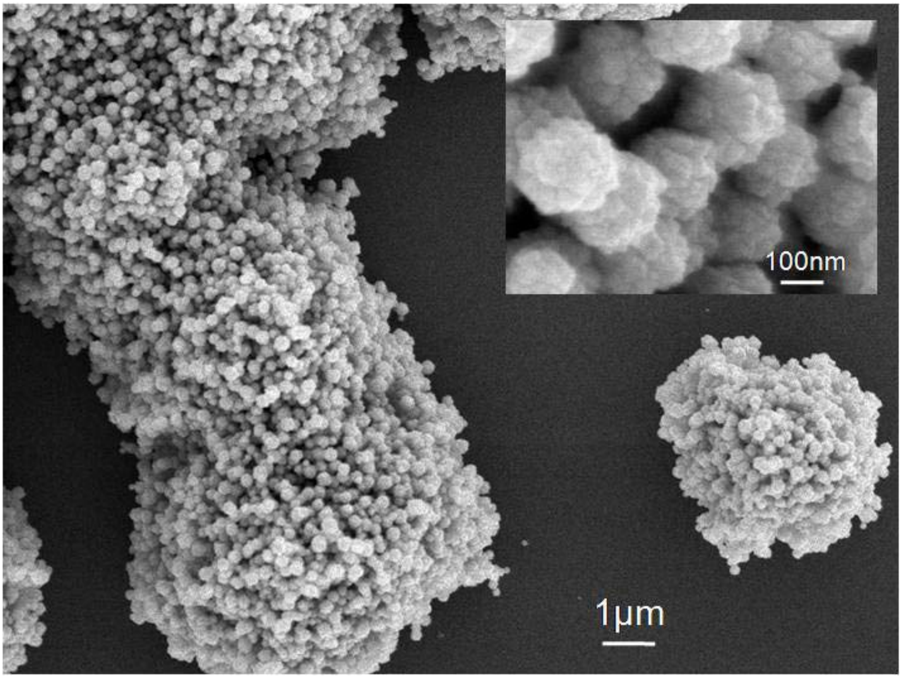
"Análisis, diseño y caracterización de componentes de óptica integrada''
MEDLUMICS-ISOM (UPM). Reference: F060001-ISOLAB001 (2012-2013)
Principal Investigator: Carlos Angulo

"Inspire- Sistemas de Almacenamiento de Energía basado en Grafeno para Vehículos Eléctricos"
REPSOL-UPM: Reference: P120920B291 (2012-2014)
Principal Investigator: Fernando Calle

"Sistema de Aterrizaje de precisión para aviones no tripulados (SAPANT)"
Ministerio de Defensa, INDRA S.A y NIT (New Infrared Technologies). Reference: Proyect COINCIDENTE 1003211004100 (2012-2014)
Principal Investigator: Álvaro de Guzmán Fernández

"Desarrollo de las actividades para la deposición con láminas III-V sobre substratos semiconductores en colaboración con Abengoa Research S.L. (Reference: Prometheus)''
Entidad: Abengoa Research S.L. Reference: Fundetel, F08-00-01 (2013-2014)
Principal Investigator: Enrique Calleja

8 DISEMINATION OF THE SCIENTIFIC ACTIVITY



Scanning Electron Microscope of conglomerates of magnetic Ni nanoparticles deposited by Sputtering. This deposition technique allows the deposition of enough material for biological applications and allows the control of the size and the composition. ISOM is currently working on medical applications of magnetic nanoparticles.

8.1 Publications in Scientific Journals and Books

2010

M. AMADO, E DIEZ, D. LÓPEZ-ROMERO, F ROSSELLA, J M CARIDAD, F DIONIGI, V BELLANID, D K MAUDE
"Plateau-insulator transition in grapheme"
New Journal of Physics 12, 053004 (2010)

M.J BAÑULS, V.GONZÁLEZ-PEDRO, C.A. BARRIOS, R. PUCHADES, Á. MAQUIEIRA
"Selective chemical modificationof silicon nitride/silicon oxide nanostructures to develop label-free biosensors"
Biosensors and Bioelectronic, 25, 1460 (2010)

M. BOZKURT, V. A. GRANT, J. M. ULLOA, R. P. CAMPION, C. T. FOXON, E. MAREGA, JR., G. J. SALAMO, P. M. KOENRAAD
"Atomic scale characterization of Mn doped InAs/GaAs quantum dots"
Applied Physics Letters, 96, 042108 (2010)

J. M. CARIDAD, F. ROSSELLA, V. BELLANI, M. MAICAS, M. PATRINI, E. DÍEZ
"Effects of particle contamination and substrate interaction in the Raman response of unintentionally doped graphene"
Journal of Applied Physics 108, 084321 (2010)

C. F. CARLBORG, K. B. GYLFASON, A. KAMIERCZAK, F. DORTOU, M. J. BAÑULS POLO, A. MAQUIEIRA CATALA, G. M. KRESBACH, H. SOHLSTRÖM, T. MOH, L. VIVIEN, J. POPPLEWELL, G. RONAN, C.A. BARRIOS, G. STEMME, W. VAN DER WIJNGAART
"A packaged optical slot-waveguide ring resonator sensor array for multiplex label-free assays in labs-on-chips"
Lab Chip, 10, 28 (2010)

P. CORFDIR, P. LEFEBVRE, L. BALET, S. SONDEREGGER, A. DUSSAIGNE, T. ZHU, D. MARTIN, J.-D. GANIÈRE, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN
"Excitons recombination dynamics in a-plane (Al,Ga)N/GaN quantum wells probed by picosecond photo and cathodoluminescence"
Journal of Applied Physics 107, 043524 (2010)

K. FOTEINOPOULOU, M. LASO
"Numerical simulation of bubble dynamics in a Phan-Thien-Tanner liquid: Non-linear shape and size oscillatory response under periodic pressure"
Ultrasonics 50, 758 (2010)

Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, D. HOSSEINI, S. ESTRADE, F. PEIRÓ, E. CALLEJA
"InAlN/GaN Bragg reflectors grown by plasma-assisted molecular beam Epitaxy"
Journal of Applied Physics, 108, 113117 (2010)

R. GAGO, M. VINNICHENKO, A. REDONDO-CUBERO, Z. CZIGÁNY, L. VAZQUEZ
"Surface Morphology of Heterogeneous Nanocrystalline Rutile/Amorphous Anatase TiO2 Films Grown by Reactive Pulsed Magnetron Sputtering"
Plasma Processes and Polymers 7, 813 (2010)

K.B. GYLFASON, C.F. CARLBORG, A.KAZMIERCZAK, F.DORTU, H. SOHLSTRÖM, L. VIVIEN, C.A. BARRIOS, W. VAN DER WIJNGAART, G. STEMM
"On-chip temperature compensation in an integrated slot-waveguide ring resonator refractive index sensor array"
Optics Express 28, 3226 (2010)

M. HOLGADO, C.A. BARRIOS, F.J. ORTEGA, F.J. SANZA, R. CASQUEL, M.F. LAGUNA, M.J. BAÑULS, D. LÓPEZ-ROMERO, R. PUCHADES, A. MAQUIEIRA
"**Label-free biosensing by means of periodic lattices of high aspect ratio SU-8 nano-pillars"**
Biosensors and Bioelectronics 25, 2553 (2010)

G.F. IRIARTE
"E-beam lithography of nano-interdigital transducers on insulating and semiconducting substrates"
Microsystem Technologies 16, 2023 (2010)

G.F. IRIARTE
"Using Transmission Electron Microscopy (TEM) for Chemical Analysis of Semiconductors"
Microscopy: Science, Technology, Applications and Education, Book Chapter, Editor: Formatex (2010)

G.F. IRIARTE
"Growth of nickel disilicide nanowires by CVD"
Journal of Non-Crystalline Solids 356, 1135 (2010)

G.F. IRIARTE
"Structural characterization of highly textured AlN thin films grown on titanium"
Journal of Materials Research 25, 458 (2010)

G.F. IRIARTE
"The influence of the magnetron on the growth of aluminium nitride thin films deposited by reactive sputtering"
Journal of Vacuum Science and Technology A 28, 193 (2010)

G.F. IRIARTE, J.G. RODRÍGUEZ, F. CALLE
"IC Compatible Synthesis of AlN for Energy Harvesting Applications"
Materia 15, 4 (2010)

G.F. IRIARTE, J.G. RODRÍGUEZ, F. CALLE
"Synthesis of c-axis oriented AlN thin films on different substrates: A review"
Materials Research Bulletin 45, 1039 (2010)

N. KARAYIANNIS, K. FOTEINOPOULOU, C. F. ABRAMS, M. LASO
"Modeling of crystal nucleation and growth in athermal polymers: self-assembly of layered nano-morphologies"
Soft Matter 6, 2160 (2010)

J. LÓPEZ-GEJO, A. ARRANZ, A. NAVARRO, C. PALACIO, E. MUÑOZ, G. ORELLANA
"Microsensors Based on GaN Semiconductors Covalently Functionalized with Luminescent Ru(II) Complexes"
J. Am. Chem Soc. 132,1746 (2010)

D. LÓPEZ-ROMERO, C.A. BARRIOS, M. HOLGADO, M.F. LAGUNA, R. CASQUEL
"High aspect-ratio SU-8 resist nano-pillar lattice by e-beam direct writing and its application for liquid trapping"
Microelectronic Engineering 87, 663 (2010)

M. MAICAS, M. SANZ, H. CUI, C. AROCA, P. SÁNCHEZ
"Magnetic properties and morphology of Ni nanoparticles synthesized in gas phase"
Journal of Magnetism and Magnetic Materials 322, 3485 (2010)

M. MAICAS, J.M. CARIDAD, F. ROSSELLA, V. BELLANI, M. PATRINI, E.DIEZ
"Effects of particle contamination and substrate interaction on the Raman response of unintentionally doped graphene"
Journal of applied physics 108, 8 (2010)

G. MENEGHESSO, F. ROSSI, G. SALVIATI, M. J. UREN, E. MUÑOZ, E. ZANONI
"Correlation between kink and cathodoluminescence spectra in AlGaN/GaN high electron mobility transistors"
Applied Physics Letters 96, 263512 (2010)

M. MONTES, A. HIERRO, J. M. ULLOA, A. GUZMÁN, M. AL KHALFIOUI, M. HUGUES, B. DAMILANO, J. MASSIES
"External efficiency and carrier loss mechanisms in InAs/GaInNAs quantum dot light emitting diodes"
Journal of Applied Physics 108, 033104/1 (2010)

M. MONTES, A. HIERRO, J. M ULLOA, J. MIGUEL-SÁNCHEZ, A. GUZMÁN, B. DAMILANO, M. HUGUES, M. AL KHALFIOUI, J.-Y. DUBOZ, J. MASSIES,
"Current spreading efficiency and Fermi level pinning in GaInNAs/GaAs quantum well laser diodes"
IEEE Journal of Quantum Electronics 46, 1058 (2010)

M. MONTES, A. GUZMÁN, A. TRAMPERT, A. HIERRO
"1.3 µm emitting GaInNAs/GaAs quantum well resonant cavity LEDs"
Solid-State Electronics 54, 492 (2010)

M.T MUÑOZ, M. MUÑOZ, M. DIAZ, T. E. GOMEZ ALVAREZ-ARENAS., H. CALAS, J. EALO, A. RAMOS
"Noncontact ultrasonic spectroscopy applied to the study of polypropylene ferroelectrets"
Journal of applied physics 108, 7 (2010)

A. NAKAMURA, T. HAYASHI, A.HIERRO, G.TABARES, J.M.ULLOA, E.MUÑOZ, J. TEMMYO,
"Schottky barrier contacts formed on polar and nonpolar MgxZn1-xO films grown by remote plasma enhanced MOCVD"
Phys. Status Solidi B 247, 1472- (2010)

J. PEDRÓS, F. CALLE, R. CUERDO, J. GRAJAL, Z. BOUGRIOUA
"Voltage tunable surface acoustic wave phase shifter on AlGaN/GaN"
Applied Physics Letters 96, 123505 (2010)

J. PEREIRO, A. REDONDO-CUBERO, S. FERNANDEZ-GARRIDO, C. RIVERA, A. NAVARRO, E. MUNOZ, E. CALLEJA, R. GAGO
"Mg doping of InGaN layers grown by PA-MBE for the fabrication of Schottky barrier photodiodes"
Journal of Physics D: Applied Physics 43, 335101 (2010)

J. L. PRIETO, P. ILG, R. BERMEJO, M. LASO
"Stochastic semi-Lagrangian micro-macro calculations of liquid crsytalline solutions in complex flows"
J. Non-Newton. Fluid Mech. 165, 185 (2010)

J.L. PRIETO, R. BERMEJO, M. LASO
"A semi-Lagrangian micro-macro method for viscoelastic flow calculations"
J. Non-Newton. Fluid Mech. 165, 120 (2010)

R. RANCHAL, J. L. PRIETO, P. SÁNCHEZ, C. AROCA
"Influence of the substrate stiffness on the crystallization process of sputtered TbFe_2 thin films"
Journal Applied Physics, 107,113918 (2010)

A. REDONDO-CUBERO, K. LORENZ, R. GAGO, N. FRANCO, M.-A. DI FORTE POISSON, E. ALVES, E. MUÑOZ
"Depth-resolved analysis of spontaneous phase separation in the growth of lattice-matched AlInN"
Journal Physics D: Appl. Phys. 43, 055406 (2010)

C. RIVERA, J. PEREIRO, A. NAVARRO, E. MUÑOZ, O. BRANDT, H.T. GRAHN,
"Advances in Group-III-Nitride Photodetectors"
The Open Electrical & Electronic Engineering Journal 4, 1 (2010)

M.F. ROMERO, M.M.SANZ, I. TANARRO, A JIMÉNEZ, E. MUÑOZ
"Plasma diagnostic and device properties of AlGaN/GaN HEMT passivated with SiN deposited by plasma enhanced chemical vapour deposition"
Journal D: Appl. Phys. 43, 495202 (2010)

N. SOFIKITI, N. CHANIOTAKIS, J. GRANDAL, M. UTRERA, M.A. SÁNCHEZ-GARCÍA, E. CALLEJA
"GaN and InN nanocolumns as electrochemical sensing elements: Potentiometric response to KCl, pH and urea"
Materials Letters 64, 1332 (2010)

E. SAKALAUSKAS, P. SCHLEY, J. RATHEL, T.A. KLAR, R. MULLER, J. PEZOLDT, K. TONISCH, J. GRANDAL, M.A. SANCHEZ-GARCIA, E. CALLEJA, A. VILALTA-CLEMENTE, P. RUTERANA, R. GOLDHAHN
"Optical properties of InN grown on Si(111) substrate"
Physica Status Solidi (a) 207, 1066 (2010)

G. TABARES, A. HIERRO, J.M. ULLOA, A. GUZMAN, E. MUÑOZ, A. NAKAMURA, T. HAYASHI, J. TEMMYO
"High responsivity and internal gain mechanisms in Au-ZnMgO Schottky photodiodes"
Applied Physics Letters 96, 101112/1 (2010)

J.M. ULLOA, P. M. KOENRAAD, M. BONNET-EYMARD, A. LÉTOUBLON, N. BERTRU
"Effect of a lattice-matched GaAsSb capping layer on the structural properties of InAs/InGaAs/InP quantum dots"
J. Appl. Phys. 107, 074309 (2010)

J.M. ULLOA, R. GARGALLO-CABALLERO, M. BOZKURT, M. DEL MORAL, P. M. KOENRAAD, A. GUZMÁN, A. HIERRO
"GaAsSb-capped InAs quantum dots: from enlarged quantum dot height to alloy fluctuations"
Physical Review B 81, 165305 (2010)

A.VILALTA-CLEMENTE, G. R.MUTTA, M. P. CHAUVAT, M. MORALES, J. L. DOUALAN, P. RUTERANA,J. GRANDAL, M. A. S ÁNCHEZ-GARCÁA, F. CALLE, E. VALCHEVA, K. KIRILOV,
"Investigation of InN layers grown by molecular beam epitaxy on GaN templates"
Physica Status Solidi (a) 207, 1079 (2010)

2011

S. ALBERT, P. LEFEBVRE, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCIA, E. CALLEJA, U. JAHN, A. TRAMPERT
"Emission control of InGaN nanocolumns grown by MBE on Si(111) substrates"
Applied Physics Letters 99, 131108 (2011)

F.J. APARICIO, M. HOLGADO, I. BLASZCZYK-LEZAK, A. BORRAS, A. GRIOL, C.A. BARRIOS, R. CASQUEL, F. J. SANZA, H. SOHLSTRÖM, M. ANTELIUS, A.R. GONZÁLEZ-ELIPE, A. BARRANCO
"Transparent nanometric organic luminescent films as UV active components in photonic structures"
Advanced Materials 23, 761 (2011)

F. BARBAGINI, A. BENGOECHEA-ENCABO, S. ALBERT, J. MARTINEZ, M.A. SANCHEZ GARCÍA, E. CALLEJA,
"Critical Aspects of Substrate Nanopatterning for Selective-Area Growth of GaN Nanocolumns"
Nanoscale Research Letters 6, 632 (2011)

C.A. BARRIOS, C. ZHENHE, F. NAVARRO-VILLOSLADA, D. LÓPEZ-ROMERO, M.C. MORENO-BONDI
“Molecularly imprinted polymer diffraction grating as label-free optical bio(mimetic)sensor"
Biosensors and Bioelectronics 26, 2801 (2011)

A. BENGOECHEA-ENCABO, F. BARBAGINI, S. FERNANDEZ-GARRIDO, J. GRANDAL, J.RISTIC, M.A. SANCHEZ-GARCIA, E. CALLEJA, U. JAHN, E. LUNA, A. TRAMPERT
"Understanding the selective area growth of GaN nanocolumns by MBE using Ti nanomasks"
Journal of Crystal Growth 325, 89 (2011)

M. BOZKURT, J.M. ULLOA, P.M. KOENRAAD
"An atomic scale study on the effect of Sb during capping of MBE grown III–V semiconductor QDs"
Science and Technology 26, 064007-1 (2011)

R. CASQUEL, M. HOLGADO, F.J. SANZA, M.F. LAGUNA, C.A. BARRIOS, D. LÓPEZ-ROMERO, F.J. ORTEGA, M.J. BAÑULS, R. PUCHADES, A. MAQUIEIRA
"Optimization of a label-free biosensor vertically characterized based on a periodic lattice of high aspect ratio SU-8 nano-pillars with a simplified 2D theoretical model"
Physica Status Solidi (c) 6, 1087 (2011)

P. COBOS, M. MAICAS, M. SANZ, C. AROCA
"High Resolution System for Nanoparticles Hyperthermia Efficiency Evaluation"
IEEE Transactions on magnetics 47, 2360 (2011)

R. CUERDO, F. CALLE
"Influence of temperature and drain current on source and drain resistances in AlGaN/GaN HEMTs"
Solid-State Electronics 63, 184 (2011)

E. CUETO, M. LASO, F. CHINESTA
"Meshless stochastic simulation of micro-macro kinetic theory models"
International Journal for Multiscale Computational Engineering 9, 1 (2011)

M. CURRIE, J. D. CALDWELL, F.J. BEZARES, J. ROBINSON, T. ANDERSON, H. CHUN, M. TADJER
"Quantifying pulsed laser induced damage to grapheme"
Applied Physics Letters 99, 211909 (2011)

K. DING, Z. LIU, L. YIN, H. WANG, R. LIU, M.T. HILL, M.J.H. MARELL, P.J. VAN VELDHOVEN, R. NÖTZEL, C.Z. DING
"Electrical injection, continuous wave operation of subwavelength-metallic-cavity lasers at 260 K"
Applied Physics Letters 98, 231108 (2011)

M.A. DUNDAR, B. WANG, R. NÖTZEL, F. KAROUTA, R.W. VAN DER HEIJDEN
"Optothermal tuning of liquid crystal infiltered InGaAsP photonic crystal nanocavities"
Journal of the Optical Society of America B-Optical Physics 28, 1514 (2011)

A. DUSSAIGNE, P.CORFDIR, J. LEVRAT, T. ZHU, D. MARTIN, P. LEFEBVRE, J.-D. GANIÈRE, B. DEVEAUD-PLÉDRAN, N. GRANDJEAN, Y. ARROYO, P. STADELMANN.
"One dimensional exciton luminescence induced by extended defects in nonpolar (Al,Ga)N/GaN quantum wells"
Semiconductor Science and Technology 26, 025012 (2011)

Z. GAČEVIĆ, A. DAS, J. TEUBERT, Y. KOTSAR, P. K. KANDASWAMY, TH. KEHAGIAS, T. KOUKOULA, PH. KOMNINOU, E. MONROY
"Internal quantum efficiency of III-nitride quantum dot superlattices growth by plasma-assisted molecular-beam epitaxy"
Journal of Applied Physics 109, 103501 (2011)

Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, J. M. REBLED, S. ESTRADÉ, F. PEIRÓ, E.CALLEJA
"High quality InAlN single layers lattice-matched to GaN grown by molecular beam epitaxy"
Applied Physics Letters 99, 031103 (2011)

J. GRANDAL, J. PEREIRO, A. BENGOECHEA-ENCABO, S. FERNÁNDEZ-GARRIDO, M.A. SÁNCHEZ-GARCÍA, E. MUÑOZ, E. CALLEJA, E. LUNA, A. TRAMPERT
"InN/InGaN multiple quantum wells emitting at 1.5 µm grown by MBE"
Applied Physics Letters 98, 061901 (2011)

A. GUZMÁN, R. SAN-ROMÁN, A. HIERRO
"Room temperature absorption in laterally biased Quantum Infrared Detectors fabricated by MBE regrowth"
Journal of Crystal Growth 323, 496 (2011)

G.F.IRIARTE
"Growth of Nickel Silicide (NiSix) Nanowires by Silane Decomposition"
Current Applied Physics 11, 82 (2011)

G.F.IRIARTE
"Large scale synthesis of silicon nanowires"
Journal of Nanoparticle Research 13, 1737 (2011)

G.F. IRIARTE, J.G.RODRÍGUEZ, F.CALLE
"Effect of substrate-target distance and sputtering pressure in the synthesis of AlN thin films"
Microsystem Technologies 17, 381 (2011)

G.F.IRIARTE, D. F. REYES, D. GONZÁLEZ, J.G.RODRIGUEZ, R. GARCÍA, F.CALLE
"Influence of substrate crystallography on the room temperature synthesis of AlN thin films by reactive sputtering"
Applied Surface Science 257,9306 (2011)

N. KARAYIANNIS, R. MALSHE, J.J. DE PABLO, M. LASO
"Fivefold symmetry as an inhibitor to hard-sphere crystallization"
Physical Review E 83, 061505 (2011)

D.R. KHANAL, A.X. LEVANDER, K.M. YU, Z. LILIENTAL-WEBER, W. WALUKIEWICZ, J. GRANDAL, E. CALLEJA, J. WU
"Decoupling Single Nanowire Mobilities Limited by Surface Scattering and Bulk Impurity Scattering"
Journal of Applied Physics 110, 033705 (2011)

X. KONG, J. RISTIĆ, E. CALLEJA, M.A. SÁNCHEZ-GARCÍA, A. TRAMPERT,
"Polarity determination by electron energy-loss spectroscopy: Application to ultra-small III-nitride semiconductor nanocolumns"
Nanotechnology 22, 415701 (2011)

P. LEFEBVRE, S. FERNÁNDEZ-GARRIDO, J. GRANDAL, J. RISTIĆ, M.A. SÁNCHEZ-GARCÍA, E. CALLEJA
"Radiative defects in GaN nanocolumns: correlation with growth conditions and sample morphology"
Applied Physics Letters 98, 083104 (2011).

J. LÓPEZ-GEJO, A. NAVARRO, A. ARRANZ, C. PALACIO, E. MUÑOZ, G. ORELLANA
"Direct Grafting of Long-Lived Luminescent Indicator Dyes to GaN Light-Emitting Diodes (LEDs) for Chemical Microsensor"
ACS Applied Materials & Interfaces 3, 3846 (2011)

P E. MALINOWSKI, J. DUBOZ, P. DE MOOR, K. MINOGLOU, J.JOHN, S.MARTIN HORCAJO, F. SEMOND, E. FRAYSSINET, P. VERHOEVE, M. ESPOSITO,B. GIORDANENGO, A. BENMOUSSA, R. MERTENS,C. VAN HOOF
"Extreme ultraviolet detection using AlGaN-on-Si inverted Schottky photodiodes"
Applied Physics Letters 98, 141104 (2011)

L. MIDOLO, P.J. VAN VELDHOVEN, M.A. DUNDAR, R. NÖTZEL, A. FIORE
"Electromechanical wavelength tuning of double-membrane photonic crystal cavities"
Applied Physics Letters 98, 211120 (2011)

MJ. MILLA, A. GUZMÁN, R.GARGALLO-CABALLERO, JM. ULLOA, A. HIERRO
"Optimization of InGaAsN(Sb)/GaAs Quantum Dots for optical emission at 1.55 µm with low optical degradation"
Journal of Crystal Growth 323, 215 (2011)

M. MONTES, J.M. ULLOA, M DEL MORAL, A. GUZMÁN, A. HIERRO
"Near Infrared InAs/GaAsSb Quantum Dot Light Emitting Diodes"
IEEE Journal of Quantum Electronics 47, 1547 (2011)

M.MUÑOZ, J.L.PRIETO
"Suppression of the intrinsic stochastic pinning of domain walls in magnetic nanostripes"
Nature Communications 2, 562 (2011)

G.R. MUTTA, J.M. ROUTOURE, B. GUILLET, L. MÉCHIN, J. GRANDAL, S. MARTÍN, T. BRAZZINI, F. CALLE, M. A. SÁNCHEZ-GARCÍA, P. MARIE, P. RUTERANA
"Volume charge carrier number fluctuations probed by low frequency noise measurements in MBE grown InN layers "
Applied Physics Letters 98, 252104 (2011).

J.L. PRIETO, M. MUÑOZ, E. MARTÍNEZ
"Structural characterization of magnetic nanostripes by fast domain wall injection"
Physical Review B 83,104425 (2011)

R. RANCHAL, E. LÓPEZ, J. L. PRIETO, C. AROCA
"Enhancement of the crystallization process of TbxFe1-x thin films upon the formation of alpha-Tb phase"
Rev. Acta Materialia 59, 2865 (2011)

R. RANCHAL, V. GONZÁLEZ-MARTÍN
"Investigation on the structural and magnetic properties of sputtered TbFe2/Fe3Ga heterostructures"
J. Appl. Phys. 110, 053901 (2011)

A. REDONDO-CUBERO, M. VINNICHENKO, M. KRAUSE, A. MUCKLICH, E. MUÑOZ et al.
"Sublattice-specific ordering of ZnO layers during the heteroepitaxial growth at different temperatures"
J. Appl. Phys. 110, 113516 (2011)

D.F.REYES, D. GONZALEZ, D. L. SALES, R. GARGALLO-CABALLERO, A. GUZMAN, J. M. ULLOA, A. HIERRO
"Inhibition of In desorption in diluted nitride InAsN QD"
Applied Physics Letters 98, 071910 (2011)

M. ROMERA, M. MUÑOZ, M. MAICAS, J. M. MICHALIK, J. M. DE TERESA, C. MAGÉN, J. L. PRIETO
"Study of the enhanced exchange and reduced magnetization of Gd in an Fe/Gd/Fe trilayer"
Physical Review 84, 094456 (2011)

M. ROMERA, R. RANCHAL, D. CIUDAD, M. MAICAS, C. AROCA
"Magnetic properties of sputtered Permalloy/molybdenum multilayers"
Journal of Applied Physics 110, 083910 (2011).

F.J. SANZA, M.F. LAGUNA, R. CASQUEL, M. HOLGADO, C.A. BARRIOS, F.J. ORTEGA, D. LÓPEZ-ROMERO, J.J. GARCÍA-BALLESTEROS, M.J. BAÑULS, A. MAQUIEIRA, R. PUCHADES,
"Cost-effective SU-8 micro-structures by DUV excimer laser lithography for label-free biosensing"
Applied Surface Science 257, 5403 (2011)

F.J. SANZA, M. HOLGADO, F.J. ORTEGA, R. CASQUEL, D. LÓPEZ-ROMERO, M.J. BAÑULS, M.F. LAGUNA, C.A. BARRIOS, R. PUCHADES, A. MAQUIEIRA
"Bio-Photonic Sensing Cells over transparent substrates for anti-gestrinone antibodies biosensing"
Biosensors and Biolectronics 26, 4842 (2011)

K. SWAMINATHAN, L. YANG, T. J. GRASSMAN, G. TABARES, A. GUZMAN, A. HIERRO, S. A. RINGEL
"Metamorphic In0.20Ga0.80As p-i-n photodetectors grown on GaAs substrates for near infrared applications"
Optics Express 19, 7280 (2011)

G. TABARES, A. HIERRO, B. VINTER, J.-M. CHAUVEAU
"Polarization-sensitive Schottky photodiodes based on a-plane ZnO/ZnMgO multiple quantum-wells"
Applied Physics Letters 99, 071108 (2011)

M. TADJER, S. MARTIN-HORCAJO, T.J. ANDERSON, R. CUERDO, K.D. HOBART, F. CALLE
"Temperature and time dependent threshold voltage characterization of AlGaN/GaN high electron mobility transistors"
Physica Status solidi c 8, 2232 (2011)

G. N. TOEPPERWEIN, N. C. KARAYIANNIS, R. A. RIGGLEMAN, M. KRÖGER, J. J. DE PABLO
"Influence of nanorod inclusions on structure and primitive path network of polymer nanocomposites at equilibrium and under deformation"
Macromolecules 44, 1034 (2011)

A. URBANCZYK, F.W.M. VAN OTTEN, R. NÖTZEL
"Self-aligned epitaxial metal-semiconductor hybrid nanostructures for plasmonics"
Applied Physics Letters 98, 243110 (2011)

B. WANG, M.A. DUNDAR, R. NÖTZEL, F. KAROUTA, S. HE, R.W. VAN DER HEIJDEN
"Spectrally encoded photonic crystal nanocavities by independent lithographic mode tuning"
Journal of the Optical Society of America B-Optical Physics 28, 721 (2011)

K. YAMAMOTO, A. NAKAMURA, J. TEMMYO, E. MUÑOZ, A. HIERRO
"Green Electroluminescence from ZnCdO Multiple Quantum Well Light-Emitting Diodes Grown by Remote-Plasma-Enhanced Metalorganic Chemical Vapor Deposition"
IEEE Photonics Technology Letters 23, 1052 (2011)

J. YUAN, H. WANG, P.J. VAN VELDHOVEN, J. WANG, T. DE VRIES, B. SMALBRUGGE, C. JIN, P. NOUWENS, E.J. GELUK, A.Y. SILOV, R. NÖTZEL
"Controlling polarization anisotropy of site-controlled InAs/InP (100) quantum dots"
Applied Physics Letters 98, 201904 (2011)

2012

S. ALBERT, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCÍA, F. BARBAGINI, E. CALLEJA, E. LUNA, A. TRAMPERT, U. JAHN,P. LEFEBVRE, L.L. LÓPEZ, S. ESTRADÉ, J.M. REBLED, F. PEIRÓ, G. NATAF, P. DE MIERRY, J. ZUÑIGA-PÉREZ
"Ordered gan/ingan nanorods arrays grown by molecular beam epitaxy for phosphor-free white light emission"
International Journal of High Speed Electronics and Systems 21, 1250010 (2012)

S. ALBERT, A. BENGOECHEA-ENCABO, P. LEFEBVRE, F. BARBAGINI, M. A. SANCHEZ-GARCIA.
"Selective area growth and characterization of InGaN nano-disks implemented in GaN nanocolumns with different top morphologies"
Applied Physics Letters 100, 231906 (2012)

N. H. ALVI, P. E. D. SOTO RODRIGUEZ, V. J. GÓMEZ, PRAVEEN KUMAR, G. AMIN et al.
"Highly efficient potentiometric glucose biosensor based on functionalized InN quantum dots"
Applied Physics Letters 101, 153110 (2012)

T. J. ANDERSON, K. D. HOBART, L. O. NYAKITI, V. D. WHEELER, R. L. MYERS-WARD, J. D. CALDWELL, F. J. BEZARES, D. K. GASKILL, C. R. EDDY, JR, F. J. KUB, G. G. JERNIGAN, M. J. TADJER, E. A. IMHOFF
"Electrical Characterization of the Graphene-SiC Heterojunction"
Materials Science Forum 717-720, 641 (2012)

T. J. ANDERSON, K. D. HOBART, L. O. NYAKITI, V. D. WHEELER, R. L. MYERS-WARD, J. D. CALDWELL, F. J. BEZARES, G. G. JERNIGAN, M. J. TADJER, E. A. IMHOFF, A. D. KOEHLER, D. K. GASKILL, C. R. EDDY, JR, F. J. KUB
"Investigation of the Epitaxial Graphene/p-SiC Heterojunction"
IEEE Electron device letters 11, 1610 (2012)

A. BENGOECHEA-ENCABO, S. ALBERT, M.A. SANCHEZ-GARCIA, L.L. LÓPEZ, S. ESTRADÉ, J.M. REBLED, F. PEIRÓ, G. NATAF, P. DE MIERY, J. ZUÑIGA, E. CALLEJA
"Selective area growth of a- and c-plane GaN nanocolumns by molecular beam epitaxy using colloidal nanolithography"
Journal Crystal Growth 353, 1 (2012)

C.A. BARRIOS, S. CARRASCO, V. CANALEJAS-TEJERO, D. LÓPEZ-ROMERO, F. NAVARRO-VILLOSLADA, M.C. MORENO-BONDI, J.L.G. FIERRO, M.C. CAPEL-SÁNCHEZ
"Fabrication of luminescent nanostructures by electron-beam direct writing of PMMA resist"
Materials Letters 88, 93 (2012)

C.A. BARRIOS
"Integrated microring resonator sensor arrays for labs-on-chips"
Analytical and Bioanalytical Chemistry 403, 1467 (2012)

C.A. C. BARRIOS, S. CARRASCO, M. FRANCESCA, P. YURRITA, F. NAVARRO-VILLOSLADA, M.C. MORENO-BONDI
"Molecularly imprinted polymer for label-free integrated optical waveguide bio(mimetic)sensors"
Sensors and Actuators B: Chemical 161, 607 (2012)

F. BARBAGINI, A. BENGOECHEA-ENCABO, S.ALBERT, P. LEFEBVRE, J. MARTINEZ, M. SANCHEZ-GARCIA, A. TRAMPERT, E. CALLEJA
"E-beam nano-patterning for the ordered growth of GaN/InGaN nanorods"
Microelectronic Engineering 98, 374 (2012)

T. BRAZZINI, A. BENGOECHEA, M.A. SÁNCHEZ-GARCÍA, F. CALLE
"Investigation of AlInN barrier ISFET structures with GaN capping for pH detection"
Sensors & Actuators: B. Chemical 176, 704 (2012)

Z. BUDRIKIS, K.L. LIVESEY, J. P. MORGAN, J. AKERMAN, A. STEIN, S.LANGRIDGE, C.H MARROWS, R.L STAMPS
"Domain dynamics and fluctuations in artificial square ice at finite temperatures"
New J. Phys. 14, 035014 (2012)

J. DÍAZ, C. QUIRÓS, L. M. ÁLVAREZ-PRADO, C. AROCA, R. RANCHAL, M. RUFFONI, S. PASCARELLI
"Determination of the magnetostrictive atomic environments in FeCoB alloys"
Physical Review B 85, 134437 (2012)

A. ELJARRAT, S. ESTRADÉ, Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, E. CALLEJA, C. MAGÉN, F. PEIRÓ
"Optoelectronic Properties of InAlN/GaN Distributed Bragg Reflector Heterostructure Examined by Valence Electron Energy Loss Spectroscopy"
Microscopy and Microanalysis 18, 1143 (2012)

F.A.I. CHAQMAQCHEE, N. BALKAN, J.M. ULLOA HERRERO
"Top-Hat HELLISH-VCSOA for optical amplification and wavelength conversion for 0.85 to 1.3μm operation"
Nanoscale Research Letters 7,525 (2012)

R. GARGALLO-CABALLERO, A. GUZMAN, J. M. ULLOA, A. HIERRO, M. HOPKINSON, E. LUNA, A. TRAMPERT
"Impact of the Ga/In ratio on the N incorporation into (In,Ga)(As,N) quantum dots"
Journal Applied Physics 111, 083530/1 (2012)

E. GUR, G. TABARES, A. AREHART, J. M. CHAUVEAU, A. HIERRO, S. A. RINGEL
"Deep levels in a-plane, high Mg-content MgxZn1-xO epitaxial layers grown by molecular beam epitaxy"
Journal Applied Physics 112, 123709/1 (2012)

G.F. IRIARTE, J.G. RODRÍGUEZ-MADRID, F. CALLE
"Fabrication of sub-100 nm IDT SAW devices on insulating, semiconducting"
Journal of Materials Processing Technology 212, 707 (2012)

N. KARAYIANNIS, R. MALSHE, M. KRÖGER, J.J. DE PABLO, M. LASO
"Evolution of fivefold local symmetry during crystal nucleation and growth in dense hard-sphere packings"
Soft. Matter. 8, 844 (2012)

J. G. KEIZER, P. M. KOENRAAD, P. SMEREKA, J. M. ULLOA, A. GUZMAN, A. HIERRO
"Kinetic Monte Carlo simulations and cross-sectional scanning tunneling microscopy as tools to investigate the heteroepitaxial capping of self-assembled quantum dots"
Physical Review B 85, 155326/1 (2012)

X. KONG, S ALBERT, A BENGOECHEA-ENCABO, M A SANCHEZ-GARCIA, E CALLEJA, A TRAMPERT
"Plasmon excitation in electron energy-loss spectroscopy for determination of indium concentration in (In,Ga)N/GaN nanowires"
Nanotechnology 23, 485701 (2012)

P. LEFEBVRE, S. ALBERT, J. RISTIĆ, S. FERNÁNDEZ-GARRIDO, J. GRANDAL, M.-A. SÁNCHEZ-GARCÍA, E. CALLEJA.
"Oxygen photo-adsorption related quenching of photoluminescence in group-III nitride nanocolumns"
Superlattices and Microstructures 52,165 (2012)

E. LUNA, A.GUZMAN, A.TRAMPERT, G. ALVAREZ
"Critical Role of Two-Dimensional Island-Mediated Growth on the Formation of Semiconductor Heterointerfaces"
Physical Review Letters 109, 126101 (2012)

J. MARTINEZ, F.BARBAGINI, A.BENGOECHEA-ENCABO, S. ALBERT, M. A. SANCHEZ GARCIA, E.CALLEJA
"Fabrication of GaN nanorods by focused ion beam"
Microelectronic Engineering 98, 250 (2012)

M.J. MILLA, J.M. ULLOA, A. GUZMÁN
"High optical sensitivity to ambient conditions of uncapped InGaAs surface quantum dots"
Applied Physics Letters 100, 133701 (2012)

A. MINJ, D. CAVALCOLI, S. PANDEY, B. FRABONI, A. CAVALLINI, T. BRAZZINI, F. CALLE
"Nanocrack-induced leakage current in AlInN/AlN/GaN"
Scripta Materialia, 66, 327 (2012)

R. NÖTZEL, A. URBANCZYK
"Epitaxial self-alignment: A new route to hybrid active plasmonic nanostructures"
Current Opinion in Solid State & Materials Science 16, 59 (2012)

F.J. ORTEGA, M-J. BAÑULS, F.J. SANZA, R. CASQUEL, M.F. LAGUNA, M. HOLGADO, D. LÓPEZ-ROMERO, C.A. BARRIOS, Á. MAQUIEIRA, R. PUCHADES
"Biomolecular Interaction Analysis of Gestrinone-anti-Gestrinone Using Arrays of High Aspect Ratio SU-8 Nanopillars"
Biosensors 2, 291 (2012)

S. PANDEY, D. CAVALCOLI, B. FRABONI, A. CAVALLINI, T. BRAZZINI, F. CALLE
"Role of surface trap states on two-dimensional electron gas density in InAlN/AlN/GaN heterostructures"
Applied Physics Letters 100, 152116 (2012).

P. PERNA, C. RODRIGO, M. MUÑOZ, J. L. PRIETO, A. BOLLERO, D. MACCARIELLO, J. L. F. CUÑADO, M. ROMERA, J. AKERMAN, E. JIMÉNEZ, N. MIKUSZEIT, V. CROS, J. CAMARERO, R. MIRANDA
"Magnetization reversal signatures in the magnetoresistance of magnetic multilayers"
Physical Review B 86, 024421 (2012)

R. RANCHAL, V. GUTIERREZ-DÍEZ, V. GONZÁLEZ-MARTÍN
"Influence of the TbFe2 crystallization effect on the magnetic and magnetostrictive properties of [Fe3Ga/TbFe2]n heterostructures."
Acta Materialia 60, 1840 (2012)

R. RANCHAL, V. GUTIÉRREZ-DÍEZ, V. GONZÁLEZ-MARTÍN
"Magnetic properties of nanostructured systems based on TbFe2"
Journal of Alloys and Compounds 536S, S329 (2012)

R. RANCHAL, Y. CHOI, M. ROMERA, J. W. FREELAND, J. L. PRIETO, D. HASKEL
"Influence of the Fe content on the Gd magnetic ordering temperature in Ni1-xFex/Gd multilayers"
Physical Review B 85, 024403 (2012)

A. REDONDO-CUBERO, A. HIERRO, J.-M. CHAUVEAU, K. LORENZ, G. TABARES, N. FRANCO, E. ALVES, E. MUÑOZ
"Single phase a-plane MgZnO epilayers for UV optoelectronics: substitutional behavior of Mg at large contents multilayers"
CrystEngComm 14, 1637 (2012)

D. F. REYES, D. GONZÁLEZ, J. M. ULLOA, D. L. SALES, L. DOMINGUEZ, A. MAYORAL, A. HIERRO
"Impact of N on the atomic-scale Sb distribution in quaternary GaAsSbN-capped InAs quantum dots"
Nanoscale Research Letters 7, 653/1 (2012)

J.G. RODRÍGUEZ-MADRID, G.F. IRIARTE, D. ARAUJO, M.P. VILLAR, O.A. WILLIAMS, W. MÜLLER-SEBERT, F. CALLE
"Optimization of AlN thin layers on diamond substrates for high frequency SAW resonators"
Materials Letters 66, 339 (2012)

J.G. RODRÍGUEZ-MADRID, G.F. IRIARTE, J. PEDRÓS, O.A. WILLIAMS, D. BRINK, F. CALLE
"High frequency AlN/Diamond/Si SAW resonators"
Electron Device Letters 33, 495 (2012)

M.F. ROMERO, A.JIMÉNEZ, F. GONZÁLEZ-POSADA FLORES, S.MARTÍN-HORCAJO, F. CALLE, E. MUÑOZ
"Impact of N2 Plasma Power Discharge on AlGaN/GaN HEMT Performance"
IEEE Transactions on Electron Devices 59, 374 (2012).

M. J. TADJER, T. J. ANDERSON, K. D. HOBART, L. O. NYAKITI, V. D. WHEELER, R. L. MYERS-WARD, D. K. GASKILL, C. R. EDDY, JR, F. J. KUB, F. CALLE
"Vertical conduction properties of few-layer epitaxial graphene / n-type 4H-SiC heterojunctions at cryogenic temperatures"
Applied Physics Letters 100, 193506 (2012)

J. M. ULLOA, J.M. LLORENS, B. ALÉN, D. F. REYES, D.L. SALES, D. GONZÁLEZ, A. HIERRO
"High efficient luminescence in type-II GaAsSb-capped InAs quantum dots upon annealing"
Applied Physics Letters 101, 253112/1 (2012)

J. M. ULLOA, D. F. REYES, M. MONTES, K. YAMAMOTO, D. L. SALES, D. GONZÁLEZ, A. GUZMAN, A. HIERRO
"Independent tuning of electron and hole confinement in InAs/GaAs quantum dots through a thin GaAsSbN capping layer"
Applied Physics Letters 100, 013107 (2012)

J. M. ULLOA, J.M. LLORENS, M. DEL MORAL, M. BOZKURT, P. M. KOENRAAD, A. HIERRO
"Analysis of the modified optical properties and band structure of GaAs1-xSbx-capped InAs/GaAs quantum dots"
Journal Applied Physics 112, 074311/1 (2012)

A. URBANCZYK, R. NÖTZEL
"Site-controlled Ag nanocrystals grown by molecular beam epitaxy-Towards plasmonic integration technology"
Journal of Applied Physics 112, 124302 (2012)

A. URBANCZYK, R. NÖTZEL
"Low-density InAs QDs with subcritical coverage obtained by conversion of In nanocrystals"
Journal of Crystal Growth 341, 24 (2012)

2013

S. ALBERT, A. BENGOECHEA-ENCABO, M.A. SÁNCHEZ-GARCÍA, E. CALLEJA, X KONG, A. TRAMPERT
"Selective area growth of In(Ga)N/GaN nanocolumns by molecular beam epitaxy on GaN-buffered Si(111): from ultraviolet to infrared emission"
Nanotechnology 24, 175303 (2013)

S. ALBERT, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCIA, E. CALLEJA, A. TRAMPERT
"Monolithic integration of blue, green, and red light emitting nanocolumnar structures for phosphor free white light emission"
Applied Physics Letters 102, 181103 (2013)

S. ALBERT, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCIA, E. CALLEJA, U. JAHN
"Selective area growth and characterization of InGaN nanocolumns for phosphor-free white light emission"
Journal of Applied Physics 113, 114306 (2013)

N. H. ALVI, V. J. GÓMEZ, P.E.D. SOTO RODRÍGUEZ, P.KUMAR, S. ZAMAN, M.WILLANDER, R.NÖTZEL
"An InN/InGaN Quantum Dot Electrochemical Biosensor for Clinical Diagnosis"
Sensors 13, 13917 (2013)

H. ALVI, V. J. GÓMEZ, P.E.D. SOTO RODRÍGUEZ, P.KUMAR, M.WILLANDER, R.NÖTZEL
"Highly Sensitive and Fast Anion-Selective InN Quantum Dot Electrochemical Sensors"
Applied Physics Express 6, 115201 (2013)

P. ASEEV, P. E. D. SOTO RODRÍGUEZ, P. KUMAR, V.J. GÓMEZ, N. H. ALVI, J. M. MANUEL, F. M. MORALES, J. J. JIMÉNEZ, R. GARCÍA, E. CALLEJA, R. NÖTZEL
"Uniform Low-to-High In Composition InGaN Layers Grown on Si"
Applied Physics Express 6, 115503 (2013)

A. BENGOECHEA-ENCABO, S. ALBERT, J. ZUÑIGA-PEREZ, A. TRAMPERT, M.A. SANCHEZ-GARCIA, E. CALLEJA
“Selective area growth and characterization of InGaN/GaN nanocolumns on semi-polar (11-22) GaN templates”
Applied Physics Letters 103, 241905 (2013)

T. BRAZZINI, A. BENGOECHEA, M.A. SÁNCHEZ-GARCÍA, F. CALLE
"Investigation of AlInN barrier ISFET structures with GaN capping for pH detection"
Sensors & Actuators: Chemical B 176, 704 (2013)

T. BRAZZINI, M.J. TADJER, Z.GACEVIC, S.PANDEY, A.CAVALLINI, F. CALLE
"Structural characterization of wet-etched quaternary InAlGaN barrier HEMT structure"
Semiconductor Science Technology 28, 055007 (2013)

T. BRAZZINI, S. PANDEY, M.F. ROMERO, P.Y. BOKOV, M. FENEBERG, G. TABARES, A. CAVALLINI, R. GOLDHAHN, F. CALLE
"Impact of AlN spacer on metal-semiconductor-metal Pt-InAlGaN/GaN heterostructures for UV detection"
Japanese Journal of Applied Physics 52, 08JK04 (2013)

V. CANALEJAS-TEJERO, S. CARRASCO, F. NAVARRO-VILLOSLADA, J.L.GARCÍA FIERRO, MC. CAPEL-SÁNCHEZ, M.C MORENO-BONDI, C.A BARRIOS
"Ultrasensitive non-chemically amplified low-contrast negative electron beam lithography resist with dual-tone behavior"
Journal of Materials Chemistry C 1, 1392 (2013)

D. CUCAK, M. VASIC, O. GARCIA, J. OLIVER, P. ALOU, J. A. COBOS, M. TADJER, F. CALLE, F. BENKHELIFA, R. REINER, P. WALTEREIT, S. MULLER
"Application of GaN FET in 1MHz Large Signal Bandwidth Power Supply for Radio Frequency Power Amplifier"
IEEE Applied Power Electronics Conference (APEC Digest), 664-671 (2013)

A. ELJARRAT, L. LÓPEZ-CONESA, C. MAGÉN, Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, E. CALLEJA, S. ESTRADÉ, F. PEIRÓ
“Insight into the Compositional and Structural Nano Features of AlN/GaN DBRs by EELS-HAADF"
Microscopy & Microanalysis, 19, 698 (2013)

C. E. CHILIOTTE, S.J.CARREIRA, V.BEKERIS, A.GÓMEZ, E.M.GONZÁLEZ, J.L.PRIETO, J.L. VICENT
"Low Temperature Vortex Dynamics in Superconducting Nb Films Containing Square and Rectangular Arrays of Ni Nanodots"
IEEE Transactions on Magnetics 49, 4643 (2013)

M. FENEBERG, M.F ROMERO, B .NEUSCHL, K. THONKE, M. ROPPISCHER et al.
"Negative spin-exchange splitting in the exciton fine structure of AlN"
Appl. Phys. Lett. 102, 052112 (2013)

A.B. FERNÁNDEZ, M.E. MCHENRY, M. DÍAZ-MICHELENA, C. AROCA, M. MAICAS
"Database of Extraterrestrial Magnetic Minerals, Test and Magnetic Simulation"
IEEE Transactions on Magnetics 49, 3533 (2013)

S. FERNÁNDEZ-GARRIDO, V. M. KAGANER, K.K. SABELFELD, T. GOTSCHKE, J.GRANDAL, E. CALLEJA, L. GEELHAAR, O. BRANDT
"Self-regulated radius of spontaneously formed GaN nanowires in molecular beam epitaxy"
Nano Letters 13, 3274 (2013)

M. FENEBERG, M.F. ROMERO, M. RÖPPISCHER, C. COBET, N. ESSER, B. NEUSCHL, K. THONKE, M. BICKERMANN, R. GOLDHAN
"Anisotropic absorption and emission on bulk (1-100) Aln"
Physical Review B 87, 235209 (2013)

Z. GACEVIC, V.J. GOMEZ, N.GARCIA LEPETIT, P.E.D. SOTO RODRIGUEZ, A. BENGOECHEA, S. FERNANDEZ-GARRIDO, R. NÖTZEL, E. CALLEJA
"A comprehensive diagram to grow metal-polarity InGaN alloys by molecular beam epitaxy"
Journal of Crystal Growth 364, 123 (2013)

Z. GACEVIC, A. ELJARRAT, F. PEIRÓ, E. CALLEJA
"Insight into high-reflectivity AlN/GaN Bragg reflectors with spontaneously formed (Al,Ga)N transient layers at the interfaces"
Journal of Applied Physics 113, 183106 (2013)

Z. GACEVIC, G. ROSSBACH, R. BUTTÉ, F. RÉVERET, M. GLAUSER, J. LEVRAT, G. COSENDEY, J.F. CARLIN, N. GRANDJEAN, E. CALLEJA
"Q-factor of (In,Ga)N containing III-nitride microcavity grown by multiple deposition techniques"
Journal of Applied Physics 114, 233102 (2013)

L. GARCÍA-GANCEDO, J. PEDRÓS, E. IBORRA, M. CLEMENT, X.B. ZHAO, J. OLIVARES, J. CAPILLA, J.K. LUO, J.R. LU, W.I. MILNE, A.J. FLEWITT
"Direct comparison of the gravimetric responsivities of ZnO-based FBARs and SMRs"
Sensors and Actuators B. 183,136 (2013)

V.J. GÓMEZ, P. E. D. SOTO RODRÍGUEZ, P.ASEEV, E. CALLEJA, R. NOËTZEL
"High In Composition InGaN for InN Quantum Dot Intermediate Band Solar Cells"
Japanese Journal of Applied Physics 52, 08JH09 (2013)

M. GHIDINI, R. PELLICELLI, J. L. PRIETO, X. MOYA, J. SOUSSI, J. BRISCOE, S. DUNN, N. D. MATHUR
"Non-volatile electrically driven repeatable magnetization reversal with no applied magnetic field"
Nature Communications 4,1453 (2013)

R.S. HOY, N.CH. KARAYIANNIS
"Simple model for chain packing and crystallization of soft colloidal polymers"
Physical Review E 88, 012601 (2013)

N.CH. KARAYIANNIS, K.FOTEINOPOULOU, M.LASO
"Spontaneous Crystallization in Athermal Polymer Packings"
International Journal Molecular Science 14, 332 (2013)

N.CH. K.ARAYIANNIS, K. FOTEINOPOULOU, M. LASO
“Jamming and Crystallization in Athermal Polymer Packings”
Philosophical Magazine 93, 4108 (2013)

P. KUMAR, P. E. D. SOTO RODRÍGUEZ, V.J. GÓMEZ, N. H. ALVI, E.CALLEJA, R. NÖTZEL
"Eliminating the buffer between InGaN and Si"
Compound Semiconductor magazine on page 61. View on line:
http://www.compoundsemiconductor.net/csc/adminpanel/uploads/magazine_images/CSApril_May2013.pdf

P. KUMAR, P. E. D. SOTO RODRÍGUEZ, V.J. GÓMEZ, N. H. ALVI, E.CALLEJA, R. NÖTZEL
"Direct growth of indium-rich InGaN on silicon"
Semiconductor Today 8, 82 (2013)

P. KUMAR, P. E. D. SOTO RODRÍGUEZ, V.J. GÓMEZ, N. H. ALVI, E.CALLEJA, R. NÖTZEL
"First Demonstration of Direct Growth of Planar High-In-Composition InGaN Layers on Si"
Applied Physics Express 6, 035501 (2013)

S.J. LEIGH, J.L. PRIETO, J. BOWEN, S. LEWIS, A.P.G. ROBINSON, P. IQBAL, J.A. PREECE
"Controlling gold nanoparticle assembly on electron beam-reduced nitrophenyl self-assembled monolayers via electron dose"
Colloids and Surfaces A- Physicochemical and Engineering Aspects 433, 181 (2013)

M. LOPEZ-PONCE, A. HIERRO, J. M. ULLOA, P. LEFEBVRE, E. MUÑOZ, S. AGOURAM, V. MUÑOZ-SANJOSE, K. YAMAMOTO, A. NAKAMURA, J. TEMMYO
"Optical properties and microstructure of 2.02-3.30 eV ZnCdO nanowires: Effect of thermal annealing"
Applied Physics Letters 102, 143103 (2013)

I. LORITE, L.PÉREZ, J.J.ROMERO, J.F.FERNANDEZ
"Effect of the dry nanodispersion procedure in the magnetic order of the Co3O4 surface
Ceramics International 39, 4377 (2013)

A. LLAVONA, L. PÉREZ, M. C. SANCHEZ, V. DE MANUEL
"Enhancement of anomalous codeposition in the synthesis of Fe–Nialloys in nanopores"
Electrochimica Acta, 106, 392 (2013)

A.LLAVONA, A. PRADOS, V. VELASCO, P. CRESPO, M. C. SÁNCHEZ, L. PÉREZ
"Electrochemical synthesis and magnetic properties of goethite single crystal nanowires"
CrystEngComm. 15, 4905 (2013)

F. LLORET, D. ARAÚJO, M.P. VILLAR, J.G. RODRÍGUEZ-MADRID, G.F. IRIARTE, O.A. WILLIAMS, F. CALLE
"Diamond underlayer microstructure effect on the orientation of AlN piezoelectric layers for high frequency SAW resonators by TEM"
Microelectronic Engineering 112, 193 (2013)

M. MANDL, X. WANG, T. SCHIMPKE, C. KOLPER, M. BINDER, J. LEDIG, A. WAAG, X. KONG, A. TRAMPERT, F. BERTRAM, J. CHRISTEN, F. BARBAGINI, E. CALLEJA, M. STRASSBURG et al
"Group III nitride core-shell nano- and microrods for optoelectronic applications"
Phys. Stat. Solidi, Rapid Research Letters 7, 800 (2013)

S. MARTÍN-HORCAJO, A.WANG, M.F ROMERO, M.J TADJER, F. CALLE
"Simple and Accurate Method to Estimate Channel Temperature and Thermal Resistance in AlGaN/GaN HEMTs"
IEEE Transactions on Electron Devices 60, 12 (2013)

M.J.MILLA, JM. ULLOA, A.GUZMAN
"Dependence of Surface InGaAs Quantum Dot Luminescence on the Molecular Properties of the Environment"
Applied Physics Express 6, 092002 (2013)

S.K. MOHANTA, A. NAKAMURA, G. TABARES, A. HIERRO, A. GUZMÁN, E. MUÑOZ, J. TEMMYO
"Electrical characterization of Schottky contacts to n-MgZnO films"
Thin Solid Films 548, 539 (2013)

J.P. MORGAN, J.AKERMAN, A.STEIN, CH. PHATAK, R. M. L. EVANS, S.LANGRIDGE, CH.H. MARROWS
"Real and effective thermal equilibrium in artificial square spin ices"
Physical Review B87, 024405 (2013)

F.J. ORTEGA, M.J BAÑULS, F.J SANZA, MF. LAGUNA, M. HOLGADO, R.CASQUEL, C.A. BARRIOS, D. LÓPEZ-ROMERO, A. MAQUIEIRA, R. PUCHADES
"Development of a versatile biotinylated material based on SU-8"
Journal of Materials Chemistry B 1, 2750 (2013)

J. PEDROS, L. GARCIA-GANCEDO, C.J.B. FORD, J.P. GRIFFITHS, G.A.C. JONES, A.J. FLEWITT
"Low attenuation of GHz Rayleigh-like surface acoustic waves in ZnO/GaAs systems immersed in liquid helium"
Applied Physics Letters 102, 043507-1 (2013)

S. RAJAPPAN ACHARY, S. AGOURAM, J.F. SÁNCHEZ-ROYO, M. LÓPEZ-PONCE, J. M. ULLOA, E. MUÑOZ, A. HIERRO, V. MUÑOZ-SANJOSÉ
"Self-assembled MgxZn1-xO quantum dots (0≤ x ≤1) on different substrates using spray pyrolysis methodology"
CrystEngComm. 15,182 (2013)

R. RANCHAL, B. S. YADAV, A. TRAMPERT
"Ferromagnetism at room temperature of c-and m-plane GaN:Gd films grown on different substrates by reactive molecular beam epitaxy"
Journal Physics D: Appl. Phys. 46, 075003 (2013)

R. RANCHAL, V. GUTIERREZ-DÍAZ
"Perpendicular magnetic anisotropy in TbFeGa ternary alloys grown by cosputtering "
Thin Solid Films 534, 557 (2013)

A. REDONDO-CUBERO, M.D. YNSA, M.F. ROMERO, L.C. ALVES, E. MUÑOZ
"Effect of rapid thermal annealing on the composition of Au/Ti/Al/Ti ohmic contacts for GaN-based microdevices"
Nuclear Instruments and Methods in Physics Research B-306, 212 (2013)

J. G. RODRÍGUEZ-MADRID, G. F. IRIARTE, O. A. WILLIAMS, F. CALLE
"High precision pressure sensors based on SAW devices in the GHz range"
Sensors and Actuators A.189, 364 (2013)

L.A. RODRÍGUEZ, C. MAGEN, E. SNOECK, C. GATEL, L. MARIN, L. SERRANO-RAMÓN, J.L. PRIETO, M. MUÑOZ, P.A. ALGARABEL, L. MORELLON, J.M. DE TERESA, M.R. IBARRA
"Quantitative in situ magnetization reversal studies in Lorentz microscopy and electron holography"
Ultramiscroscopy 134, 144 (2013).

M. ROMERA, J. GROLLIER, S.COLLIN, T. DEVOLDER, V. CROS, M. MUÑOZ, JL PRIETO
"Enhanced stability in spin transfer nanopillars due to a Fe/Gd/Fe trilayer"
Applied Physics Letters 103, 122404 (2013)

M.F. ROMERO, M. FENEBERG, P. MOSER, C. BERGER, J. BLASING, A. DADGAR, A. KROST, E. SAKALAUSKAS, F. CALLE, R. GOLDHAHN
"Systematic optical characterization of two-dimensional electron gases in InAlN/GaN-based heterostructures with different in content"
Japanese Journal of Applied Physics Physics 52, 08JK02 (2013)

A. SASIKUMAR, A. R. AREHART, S. MARTIN-HORCAJO, M. F. ROMERO, Y. PEI, D. BROWN, F. RECHT, M. A. DI FORTE-POISSON, F. CALLE, M. J. TADJER, S. KELLER, S. P. DENBAARS, U. K. MISHRA, S. A. RINGEL,
"Direct comparison of traps in InAlN/GaN and AlGaN/GaN high electron mobility transistors using constant drain current deep level transient spectroscopy"
Applied Physic Letters 103, 033509 (2013)

J. SCHIEFELE, J. PEDRÓS, F. SOLS, F. CALLE, F. GUINEA
Coupling light into graphene plasmons with the help of surface acoustic waves.
Physical Review Letters 111, 237405-1 (2013)

P.E. D. SOTO RODRÍGUEZ, VJ. GÓMEZ, P. KUMAR, E.CALLEJA, R. NÖTZEL
"Near-infrared InN quantum dots on high-In composition InGaN"
Applied Physics Letters 102, 131909 (2013)

P. E. D. SOTO RODRÍGUEZ, P. KUMAR, V. J. GÓMEZ, N. H. ALVI, J. M. MANUEL, F. M. MORALES, J. J. JIMÉNEZ, R. GARCÍA, E. CALLEJA, R. NÖTZEL
"Spontaneous formation of InGaN nanowall network directly on Si "
Appl. Phys. Lett. 102, 173105 (2013)

MJ. TADJER, A. CONSTANT, P. GODIGNON, S.MARTIN-HORCAJO, A. BOSCA, F. CALLE, M. BERTHOU, J. MILLAN
"Gate oxide stability of 4H-SiC MOSFETs under On/Off state bias-temperature stress"
Materials Science Forum 740-742, 553 (2013)

A. URBANCZYK, JG. KEIZER, PM. KOENRAAD, R. NÖTZEL
“Long wavelength (> 1.55 mu m) room temperature emission and anomalous structural properties of InAs/GaAs quantum dots obtained by conversion of In nanocrystals”
Applied Physics Letters 102, 073103 (2013)

D. UTRILLA, J. M. ULLOA, A. GUZMAN, A. HIERRO
“Impact of the Sb content on the performance of GaAsSb-capped InAs/GaAs quantum dot lasers”
Applied Physics Letters 103, 111114/1 (2013)

A. WANG, M.J. TADJER, F. CALLE
"Simulation of thermal management in AlGaN/GaN HEMTs with integrated diamond heat spreaders"
Semiconductor Science Technology 28, 055010 (2013)

A. WANG, M. J. TADJER, T. J. ANDERSON, R. BARANYAI, J. W. POMEROY, T. I. FEYGELSON, K. D. HOBART, B. B. PATE, F. CALLE, M. KUBALL
"Impact of intrinsic stress in diamond capping layers on the electrical behavior of AlGaN/GaN HEMTs"
IEEE Trans. Electron Devices 60, 3149 (2013)

JY. YUAN, CY. JIN, M. SKACEL, A. URBANCZYK, T.XIA, PJ. VAN VELDHOVEN, R. NÖTZEL
"Coupling of InAs/InP quantum dots to the plasmon resonance of In nanoparticles grown by metal-organic vapor phase epitaxy"
Applied Physics Letters 102, 191111 (2013)

2014

M. ABUÍN,L. PÉREZ, A. MASCARAQUE and M. MAICAS
"**Tuning the magnetic properties of FeCo by pulsed DC magnetron sputtering**"
CrystEngComm 16, 9528 (2014)

JOHANNA AKERMAN, MANUEL MUÑOZ, MARCO MAICAS and JOSÉ L. PRIETO
"**Selective injection of magnetic domain walls in Permalloy nanostripes**"
J. Appl. Phys. 115, 183909 (2014)

STEVEN ALBERT, ANA MARIA BENGOECHEA-ENCABO, FRANCESCA BARBAGINI, DAVID LOPEZ-ROMERO, MIGUEL ANGEL SANCHEZ-GARCIA and ENRIQUE CALLEJA
"**Advances in MBE Selective Area Growth of III-Nitride Nanostructures: From NanoLEDs to Pseudo Substrates**"
International Journal of High Speed Electronics and Systems 23, 1450020 (2014)

S. ALBERT, A.BENGOECHEA-ENCABO, M.SABIDO-SILLER, M.MÜLLER, G.SCHMIDT, S. METZNER, P.VEIT, F.BERTRAM, M.A.SÁNCHEZ-GARCÍA, J.CHRISTEN, E.CALLEJA
"**Growth of InGaN/GaN core–shell structures on selectively etched GaN rods by molecular beam epitaxy**"
Journal of Crystal Growth 392, 5 (2014)

S. ALBERT, A. BENGOECHEA-ENCABO, J. ZUNIGA-PEREZ, P. DE MIERRY, P. VAL, M. A. SANCHEZ-GARCIA, E. CALLEJA
"**Selective area growth of GaN nanostructures: A key to produce high quality (11–20) aplane pseudo-substrates**"
Applied Physics Letters 105, 091902 (2014)

N. H. ALVI, P. E. D. SOTO RODRIGUEZ, PRAVEEN KUMAR, V. J. GÓMEZ, P. ASEEV, A. H. ALVI, M. A. ALVI, M. WILLANDER and R. NÖTZEL
"**Photoelectrochemical water splitting and hydrogen generation by a spontaneously formed InGaN nanowall network**"
Appl. Phys. Lett. 104, 223104 (2014)

C. A. BARRIOS, V. CANALEJAS-TEJERO, S. HERRANZ, M. C. MORENO-BONDI, M. AVELLA-OLIVER, R. PUCHADES, A. MAQUIEIRA
"**Aluminum Nanohole Arrays Fabricated on Polycarbonate for Compact Disc-Based Label-Free Optical Biosensing**"
Plasmonics 9, 645 (2014)

A BENGOECHEA-ENCABO, S ALBERT, D LOPEZ-ROMERO, P LEFEBVRE, F BARBAGINI, A TORRES-PARDO, J M GONZALEZ-CALBET, M.A. SANCHEZ-GARCIA and E CALLEJA
"**Light-Emitting-Diodes based on ordered InGaN nanocolumns emitting in the blue, green and yellow spectral range**"
Nanotechnology 25, 435203 (2014)

T BRAZZINI, S MARTIN-HORCAJO, M F ROMERO, Ž GACĔVIĆ and F CALLE
"**Analysis of InAl(Ga)N/GaN wet-etching by structural, morphological and electrical methods**"
Semicond. Sci. Technol. 29, 075003 (2014)

VÍCTOR CANALEJAS-TEJERO, SONIA HERRANZ, ALYSSA BELLINGHAM, MARÍA CRUZ MORENO-BONDI and CARLOS ANGULO BARRIOS
"**Passivated Aluminum Nanohole Arrays for Label-Free Biosensing Applications**"
Appl. Mater. Interfaces 6, 1005 (2014)

S. CARRASCO, V. CANALEJAS-TEJERO, F. NAVARRO-VILLOSLADA, C. A. BARRIOS and M. C. MORENO-BONDI
"**Cross-linkable linear copolymer with double functionality: resist for electron beam nanolithography and molecular imprinting**"
J. Mater. Chem. C 2, 1400 (2014)

CHEN WU, NIKOS CH. KARAYIANNIS, MANUEL LASO, DONGDONG QU, QIANG LUO,JUN SHEN
"**A metric to gauge local distortion in metallic glasses and supercooled liquids**"
Acta Materialia 71, 229 (2014)

D. CUCAK, M. VASIC, O. GARCIA, Y. BOUVIER, J. OLIVER, P. ALOU, J.A. COBOS, A. WANG, S. MARTIN-HORCAJO, F. ROMERO, F. CALLE
"**Physical Model for GaN HEMT Design Optimization in High Frequency Switching Applications**"
Solid State Device Research Conference (ESSDERC), p. 393 (2014)

B. DEV CHOUDHURY, R. CASQUEL, M.J. BAÑULS, F.J. SANZA, M.F. LAGUNA, M. HOLGADO, R. PUCHADES, A. MAQUIEIRA, C.A. BARRIOS and S. ANAND
"**Silicon nanopillar arrays with SiO2 overlayer for biosensing application**"
Optical Materials Express 4, 1345 (2014)

A GOMEZ, J DEL VALLE, E M GONZALEZ, C E CHILIOTTE, S J CARREIRA, V BEKERIS, J L PRIETO, IVAN K SCHULLER and J L VICENT
"**Vortex pinning vs superconducting wire network: origin of periodic oscillations induced by applied magnetic**"
Supercond. Sci. Technol. 27, 065017 (2014)

D. F. GROSSI, P. SMEREKA, J. G. KEIZER, J. M. ULLOA and P. M. KOENRAAD
"**Height control of self-assembled quantum dots by strain engineering during capping**"
Appl. Phys. Lett. 105, 143104 (2014)

A. HAMADEH, O. D'ALLIVY KELLY, C. HAHN, H. MELEY, R. BERNARD, A. H. MOLPECERES, V. V. NALETOV, M. VIRET, A. ANANE, V. CROS, S. O. DEMOKRITOV, J. L. PRIETO, M. MUÑOZ, G. DE LOUBENS and O. KLEIN
"**Full Control of the Spin-Wave Damping in a Magnetic Insulator Using Spin-Orbit Torque**"
Phys. Rev. Lett. 113, 197203 (2014)

C. HAHN, V. V. NALETOV, G. DE LOUBENS, O. KLEIN, O. D'ALLIVY KELLY, A. ANANE, R. BERNARD, E. JACQUET, P. BORTOLOTTI, V. CROS, J. L. PRIETO and M. MUÑOZ
"**Measurement of the intrinsic damping constant in individual nanodisks of Y3Fe5O12 and Y3Fe5O12|Pt**"
Appl. Phys. Lett. 104, 152410 (2014)

NIKOS CH. KARAYIANNIS, KATERINA FOTEINOPOULOU and MANUEL LASO
"**Twinning of Polymer Crystals Suppressed by Entropy**"
Symmetry 6, 758 (2014)

J. G. KEIZER, J. M. ULLOA, A. D. UTRILLA and P. M. KOENRAAD
"**InAs quantum dot morphology after capping with In, N, Sb alloyed thin films**"
Appl. Phys. Lett. 104, 053116 (2014)

A. KURTZ, A. HIERRO, E. MUÑOZ, S. K. MOHANTA, A. NAKAMURA AND J. TEMMYO
"**Acceptor levels in ZnMgO:N probed by deep level optical spectroscopy"**
Appl. Phys. Lett. 104, 081105 (2014)

A. LARA, O. V. DOBROVOLSKIY, J. L. PRIETO, M. HUTH and F. G. ALIEV
"**Magnetization reversal assisted by half antivortex states in nanostructured circular cobalt disks circular cobalt disks**"
Appl. Phys. Lett. 105, 182402 (2014)

M LOPEZ-PONCE, A NAKAMURA, M SUZUKI, J TEMMYO, S AGOURAM, M C MARTÍNEZ-TOMÁS, V MUÑOZ-SANJOSÉ, P LEFEBVRE, J M ULLOA, E MUÑOZ and A HIERRO
"**VIS-UV ZnCdO/ZnO multiple quantum well nanowires and the quantification of Cd diffusion**"
Nanotechnology 25, 255202 (2014)

ESPERANZA LUNA, JAVIER GRANDAL, EVA GALLARDO, JOSÉ M. CALLEJA, MIGUEL Á. SÁNCHEZ-GARCÍA, ENRIQUE CALLEJA and ACHIM TRAMPERT
"**Investigation of III–V Nanowires by Plan-View Transmission Electron Microscopy: InN Case Study**"
Microsc. Microanal. 20, 1471 (2014)

S MARTIN-HORCAJO, A WANG, M F ROMERO, M J TADJER, A D KOEHLER, T J ANDERSON and F CALLE
"**Impact of device geometry at different ambient temperatures on the self-heating of GaN-based HEMTs**"
Semicond. Sci. Technol. 29, 115013 (2014)

M J MILLA, J M ULLOA and A GUZMÁN
"**Photoexcited-induced sensitivity of InGaAs surface QDs to environment**"
Nanotechnology 25, 445501 (2014)

M. J. MILLA, J. M. ULLOA and Á. GUZMÁN
"**Strong Influence of the Humidity on the Electrical Properties of InGaAs Surface Quantum Dots**"
Appl. Mater. Interfaces 6, 6191 (2014)

ANA PÉREZ-CAMPOS, GONZALO FUENTES IRIARTE, VADIM LEBEDEV and FERNANDO CALLE
"**PostCMOS compatible sacrificial layers for aluminum nitride microcantilevers**"
J. Micro/Nanolith. MEMS MOEMS. 13, 043012 (2014)

P. PERNA, D. MACCARIELLO, C. RODRIGO J. L. F. CUÑADO, M. MUÑOZ, J. L. PRIETO, M. A. NIÑO, A. BOLLERO, J. CAMARERO and R. MIRANDA
"**Direct experimental determination of the anisotropic magnetoresistive effects**"
Appl. Phys. Lett. 104, 202407 (2014)

R. RANCHAL, S. FIN, D. BISERO, C. AROCA
"**Tailoring the magnetic anisotropy and domain patterns of sputtered TbFeGa alloys**"
Journal of Alloys and Compounds 582, 839 (2014)

GEETA RANI MUTTA, TOMMASO BRAZZINI, LAURENCE MÉCHIN, BRUNO GUILLET, JEAN-MARC ROUTOURE, JEAN-LOUIS DOUALAN, JAVIER GRANDAL, MARIA DEL CARMEN SABIDO SILLER, FERNANDO CALLE and PIERRE RUTERANA
"**Influence of fabrication steps on optical and electrical properties of InN thin films**"
Semicond. Sci. Technol. 29, 095010 (2014)

A REDONDO-CUBERO, L VÁZQUEZ, L C ALVES, V CORREGIDOR, M F ROMERO, A PANTELLINI, C LANZIERI and E MUÑOZ
"**Influence of lateral and in- depth metal segregation on the patterning of ohmic contacts for GaN-based devices**"
J. Phys. D: Appl. Phys. 47, 185302 (2014)

W. SCHOENTHAL, X. LIU, T. COX, J. L. MESA, M. MAICAS, M. DIAZ-MICHELENA, D. E. LAUGHLIN and M. E. MCHENRY
"**Synthesis and magnetic properties of single phase titanomagnetites**"
J. Appl. Phys. 115, 17A934 (2014)

MARKO J. TADJER, MICHAEL A. MASTRO, JOSÉ M. ROJO, ALBERTO BOSCÁ MOJENA, FERNANDO CALLE, FRANCIS J. KUB, CHARLES R. EDDY JR.
"**MnO2-Based Electrochemical Supercapacitors on Flexible Carbon Substrates**"
Journal of Electronic Materials 43, 1188 (2014)

M.J. TADJER, K.D. HOBART, T.J. ANDERSON, T.I. FEYGELSON, R.L. MYERS-WARD, A.D. KOEHLER, F. CALLE, C.R. EDDY, D.K. GASKILL, B.B. PATE, F.J. KUB
"**Thermionic-Field Emission Barrier Between Nanocrystalline Diamond and Epitaxial 4H-SiC**"
IEEE Electron Device Lett. 35, 1173 (2014)

J. M. ULLOA, D. F. REYES, A. D. UTRILLA, A. GUZMAN, A. HIERRO, T. BEN and D. GONZÁLEZ
"**Capping layer growth rate and the optical and structural properties of GaAsSbN-capped InAs/GaAs quantum dots**"
J. Appl. Phys. 116, 134301 (2014)

A. D. UTRILLA, D. F. REYES, J. M. ULLOA, D. GONZÁLEZ, T. BEN, A. GUZMAN and A. HIERRO
"**GaAsSb/GaAsN short-period superlattices as a capping layer for improved InAs quantum dot-based optoelectronics**"
Appl. Phys. Lett. 105, 043105 (2014)

ANTONIO D UTRILLA, JOSE M ULLOA, ALVARO GUZMAN, ADRIAN HIERRO
"**Long-wavelength room-temperature luminescence from InAs/GaAs quantum dots with an optimized GaAsSbN capping layer**"
Nanoscale Research Letters 9, 36 (2014)

J. L. URRACA, C. A. BARRIOS, V. CANALEJAS-TEJERO, G. ORELLANA and M. C. MORENO-BONDI
"**Molecular recognition with nanostructures fabricated by photopolymerization within metallic subwavelength apertures**"
Nanoscale 6, 8656 (2014)

J.L. URRACA, M. CASTELLARI, C.A. BARRIOS, M.C. MORENO-BONDI
"**Multiresidue analysis of fluoroquinolone antimicrobials in chicken meat by molecularly imprinted solid-phase extraction and high performance liquid chromatography**"
Journal of chromatography 1343, 1 (2014)

8.2 Conferences and Meetings

2010

M. ABUÍN. M. PLAZA, M.A. GONZÁLEZ-BARRIO, A. MASCARAQUE, L. PÉREZ
"Influence of GaAs surface orientation on electrodeposited Bi thin films"
ECOSS-27: 27th European Conference on Surface
Groningen (Netherlands), 2010

M. ABUÍN. M. PLAZA, M.A. GONZÁLEZ-BARRIO, A. MASCARAQUE, L. PÉREZ
"Estudio del crecimiento de películas delgadas de Bismuto sobre superficie semiconductora ".
XI Congreso Nacional de Materiales 2010
Zaragoza (Spain), 2010

S. ALBERT, J. GRANDAL, M.A. SANCHEZ-GARCIA, P. LEFEBVRE, J. RISTIĆ, E. CALLEJA, A. VILALTA-CLEMENTE, B. LACROIX, P. RUTERANA, E. LUNA, U. JAHN, A. TRAMPERT.
"MBE growth and characterization of InN/InGaN thin films and nanostructures on GaN templates and Si(111) substrates"
16th International MBE Conference
Berlin (Germany), 2010

M.J. BAÑULS, F.J. ORTEGA, M.F. LAGUNA, M. HOLGADO, C.A. BARRIOS, R. CASQUEL, F.J. SANZA, D. LÓPEZ-ROMERO, A. MAQUIEIRA, R. PUCHADES
"Chemical surface functionalization of polymeric based materials to develop nanobiosensors"
TechConnect World Conference and Expo 2010
Anaheim (USA), 2010

C.A. BARRIOS, C. ZHENHE, F. NAVARRO VILLOSLADA, D. LÓPEZ ROMERO, M.C. MORENO BONDI
"Micropatterned Molecularly Imprinted Polymers as Label Free Optical Sensors"
MIP 2010
Nueva Orleans (USA), 2010

A. BENGOECHEA, J. GRANDAL, S. FERNANDEZ-GARRIDO, M.A. SANCHEZ-GARCIA, F. BARBAGINI, P. LEFEBVRE, E. CALLEJA, E. LUNA, A. TRAMPERT.
"Selective area growth of GaN nanocolumns by rf-plasma-assisted MBE"
16th International MBE Conference
Berlin (Germany), 2010

T. BRAZZINI, J. GRANDAL, A. PRADO, A. VILLATA-CLEMENTE, F. CALLE
"InN-based material devices for infrared photodetection"
19th European Workshop on Heterostructures Technology
Crete (Greece), 2010

R. CASQUEL, M. HOLGADO, F.J. SANZA, M.F. LAGUNA, C.A. BARRIOS, D. LÓPEZ-ROMERO, F.J. ORTEGA, M.J. BAÑULS, R. PUCHADES, A. MAQUIEIRA.
"Optimization of a label-free biosensor vertically characterized based on a periodic lattice of high aspect ratio SU-8 nano-pillars with a simplified 2D theoretical mode"
European Material Research Society (E-MRS)
Estrasburgo (France), 2010

P. CORFDIR, P. LEFEBVRE, A. DUSSAIGNE, L. BALET, S. SONDEREGGER, T. ZHU, D. MARTIN, J.-D. GANIÈRE, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN
"Exciton dynamics in a-plane (Al,Ga)N/GaN single quantum wells grown by molecular beam epitaxy on ELO-GaN"
International Workshop on Nitride Semiconductors – IWN 2010
Tampa (USA), 2010

P. CORFDIR, P. LEFEBVRE, A. DUSSAIGNE, J. RISTIĆ, T. ZHU, D. MARTIN, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN, J.-D. GANIÈRE.
"Exciton relaxation and recombination mechanisms in a-plane GaN probed by time-resolved cathodoluminescence"
10th International Workshop on Beam Injection Assessment of Microstructures in Semicond - BIAMS 2010
Halle (Germany), 2010

P. CORFDIR, A. DUSSAIGNE, P. LEFEBVRE, H. TEISSEYRE, J.-D. GANIÈRE, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN
"Radiative lifetimes of localized and free excitons in homoepitaxial non-polar (Al,Ga)N/GaN single quantum well"
39th International School and Conference on the Physics of Semiconductors
Jaszowiec (Poland), 2010

P. CORFDIR, D. SIMEONOV, E. FELTIN, J.-F. CARLIN, P. LEFEBVRE, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN, J.-D. GANIÈRE.
"Time resolved cathodoluminescence on InGaN/GaN quantum wells grown on non-coalesced ELO-GaN"
10th International Workshop on Beam Injection Assessment of Microstructures in Semicond - BIAMS 2010
Halle (Germany), 2010

P. CORFDIR, P. LEFEBVRE, J.-D. GANIÈRE, B. DEVEAUD-PLÉDRAN.
"Distortion of donor properties in III-nitride based nano-scale systems"
International Workshop on Nitride Semiconductors – IWN 2010
Tampa (USA), 2010

P. CORFDIR, A. DUSSAIGNE, P. LEFEBVRE, H. TEISSEYRE, T. SUSKI, I. GRZEGORY, J.D. GANIÈRE, N. GRANDJEAN, B. DEVEAUD-PLÉDRAN
"Radiative Recombination Limited Lifetimes in a-plane (Al,Ga)N/GaN single quantum wells grown on GaN"
International Workshop on Nitride Semiconductors – IWN 2010
Tampa (USA), 2010

R. CUERDO, J. GRAJAL, F. CALLE
"Power Performance of AlGaN/GaN HEMTs as a Function of Temperature"
34th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE 2010
Seeheim-Darmstadt (Germany), 2010

S. FERNÁNDEZ-GARRIDO, J. GRANDAL, P. LEFEBVRE, M.A. SÁNCHEZ-GARCÍA, E.CALLEJA.
"GaN nanocolumns grown on Si(111) by plasma-assisted MBE: Correlation of structural and optical properties with growth parameters"
International Simposium on Growth of III Nitrides (ISGN3)
Montpellier (France), 2010

A.GUZMÁN FERNÁNDEZ, R. GARGALLO-CABLLERO, MJ. MILLA, JM. ULLOA, A. HIERRO
"Low optical degradation in InGaAsN/GaAs Quantum Dot p-i-n structures emitting from 1.1 to 1.55 µm"
16th International MBE Conference
Berlín (German), 2010

A.GUZMÁN FERNÁNDEZ, R. SAN-ROMÁN, A.HIERRO
"Laterally biased double quantum well IR detector fabricated by MBE regrowth"
6th International Conference on Molecular Beam Epitaxy
Berlín (Germany), 2010

G.F. IRIARTE
"Large scale synthesis of nanostructures"
XIX International Materials Research Congress
Cancún Quintana Roo (Mexico), 2010

G.F. IRIARTE, J.G. RODRÍGUEZ, F. CALLE
"IC Compatible Synthesis of AlN for Energy Harvesting Applications"
Materia Symposium 2010
Rio de Janeiro (Brazil), 2010

A. JAVORSKY, M. M. SANZ, F. MAESTÚ, J.M. GAZTELU, M. MAICAS, J. GARCÍA-PACIOS, M. ROMERO-VIVES, J.A. BARIOS, F. DEL POZO, C. AROCA
" Detection system of magnetic nanoparticules in biological tissues by magnetoencephalography"
Magnetic Measurements 2010
Praga (Czech Republic), 2010

P. LEFEBVRE, S. ALBERT, J. RISTIĆ, M.-A. SÁNCHEZ-GARCÍA, E. CALLEJA.
"Carrier localization and surface effects in InGaN nanocolumns grown by plasma-assisted molecular beam epitaxy"
International Workshop on Nitride Semiconductors – IWN 2010
Tampa (USA), 2010

J. LÓPEZ-GEJO , A. ARRANZ, A. NAVARROC, C. PALACIO, E. MUÑOZ, G. ORELLANA
"New integrated oxygen sensors based on GaN emitters covalently funcionalized with luminiscent Ru(II) complexes"
X European Conference on Optical Sensors and Biosensors
Praga (Czech Republic), 2010

A. LLAVONA, T. FERNÁNDEZ, M. RAMOS, V. DE MANUEL, M.C. SÁNCHEZ, L. PÉREZ
"7-Aminoheptanoic acid coated cobalt nanowires for biomedical applications"
Bio-Coat 2010
Zaragoza (Spain), 2010

M. MAICAS, M. SANZ LLUCH, C. AROCA
"Synthesis of Fe-Au nanoparticles throug phase separation using the gas aggregation te chnique"
7th International Conference of Fine particle magnetic materials
Uppsala (Sweden), 2010

S. MARTÍN-HORCAJO, R. CUERDO, E. SILLERO, F. CALLE
"Self-heating effects in algan/gan hemts at high temperature"
34th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE 2010
Seeheim-Darmstadt (Germany), 2010

S. MARTÍN-HORCAJO, M. J. TADJER, R. CUERDO, M. F. ROMERO, F. CALLE
"Evaluation of the thermal stability in D-mode and E-mode HEMTs based on AlGaN/GaN"
19th European Workshop on Hetectostructure HETECH 2010
Creta (Greece), 2010

G. MENEGHESSO, A. STOCCO, N. RONCHI, E. ZANONI, R. CUERDO, F. CALLE, E. MUNOZ, M.J. UREN
"Correlation between kink and Cathodoluminescence in AlGaN/GaN HEMTs"
34th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE 2010
Seeheim-Darmstadt (Germany), 2010

F.J. ORTEGA, M.J. BAÑULS, M.F. LAGUNA, F.J. SANZA, M. HOLGADO, C.A. BARRIOS, R. CASQUEL, D. LÓPEZ-ROMERO, A. MAQUIEIRA, R. PUCHADES.
"Biosensado sin marcaje en nanopilares de SU-8"
IV Workshop on Sensors and Molecular Recognition
Valencia (Spain), 2010

J.L PRIETO, J. AKERMAN, M. MAICAS
"Experimental Study of the Micromagnetic Structure of a Domain Wall Pinned in double notches of different shapes"
56th Annual Conference on Magnetism and Magnetic Materals
Arizona (USA), 2010

R. RANCHAL, V. GONZALEZ-MARTÍN, C. AROCA, E. LÓPEZ
"Structural and magnetic properties of TbFe2/Fe3Ga heteroestructures growth by sputtering"
56th Annual Conference on Magnetism and Magnetic Materals
Arizona (USA), 2010

D.F. REYES, D.L. SALES, R. GARGALLO-CABALLERO, J.M.ULLOA, A. HIERRO, A. GUZMÁN, D. GONZÁLEZ
"Effects of the nitrogen incorporation in the optical and structural characteristics of nitrogen-dilute InAsN QDs"
European Materials Research Society Spring Meeting 2010
Strasbourg (France), 2010

D.F. REYES, D.L. SALES, R. GARGALLO-CABALLERO, J.M.ULLOA, A. HIERRO, A. GUZMÁN, D. GONZÁLEZ
"Efecto de la incorporación de nitrógeno en puntos cuánticos enterrados de in In(Ga)As crecidos sobre GaAs"
Congreso Nacional de Materiales
Zaragoza (Spain), 2010

J.G RODRÍGUEZ, G. FUENTES, O. WILLIAMS, F. CALLE
"The Influence of the Substrate Roughness on the c-Axis Orientation of AlN/Diamond Thin Films"
10th Workshop on Expert Materials Characterization and Technologies, EXMATEC 2010.
Seeheim-Darmstadt (Germany) 2010

F.J. SANZA, R. CASQUEL, D. LÓPEZ-ROMERO, M.F. LAGUNAS, M. HOLGADO, C.A. BARRIOS, M.J. BAÑULS, F.J. ORTEGA, R. PUCHADES, A. MAQUIEIRA.
"Label-free biosensing by means of periodic lattices of high aspect-ratio SU8 nanopillars"
BIOSENSORS 2010
Glasgow (UK), 2010

F.J. SANZA, M. HOLGADO, R. CASQUEL, M.F. LAGUNA, D. LÓPEZ-ROMERO, C.A. BARRIOS, M.J. BAÑULS, F.J. ORTEGA, R. PUCHADES, A. MAQUIEIRA
"Label-free biosensing by means of periodic lattices of SU8 nanopillars"
EUROPTRODE X
Praga (Czech Republic), 2010

F.J. SANZA, M.F. LAGUNA, R. CASQUEL, M. HOLGADO, C.A. BARRIOS, F.J. ORTEGA, D. LÓPEZ-ROMERO, J.J. GARCÍA-BALLESTEROS, M.J. BAÑULS, A. MAQUIEIRA, R. PUCHADES
"Cost-effective SU-8 micro-structures by DUV excimer laser lithography for label-free biosensing"
European Material Research Society (E-MRS)
Estrasburgo (France), 2010

G. TABARES, A. HIERRO, C. DEPARIS, C. MORHAIN, J-M. CHAUVEAU
"Polarization-Sensitive Schottky Photodiodes Based on A-Plane ZnO/ ZnMgO Multiple Quantum-Wells"
52nd Electronic Materials Conference 2010
Indiana (USA), 2010

M. J. TADJER, R. CUERDO, T. J. ANDERSON, K. D. HOBART, S. MARTÍN-HORCAJO, F. CALLE
"Comparative study of threshold voltage stability in enhancement mode AlGaN/GaN HEMTs"
International Workwhop on Nitrides
Tampa (EEUU), 2010

J.M. ULLOA, R. GARGALLO-CABALLERO, A. GUZMÁN, A. HIERRO
"GaAsSbN-capped InAs quantum dots for 1.3 – 1.55 µm emission"
European Materials Research Society Spring Meeting 2010
Strasbourg (France), 2010

J. M. ULLOA, M. DEL MORAL, M. BOZKURT, R. GARGALLO-CABALLERO, A. GUZMÁN, P. M. KOENRAAD, A. HIERRO
"GaAsSb-capped InAs quantum dots: from enlarged quantum dot height to alloy fluctuations"
Internacional Quantum Dot Conference 2010
Nottinghan (UK), 2010

J.M. ULLOA, P.M. KOENRAAD, M. HOPKINSON
"Structural properties of GaAsN/GaAs quantum wells studied at the atomic scale by cross-sectional scanning tunneling microscopy"
European Materials Research Society Spring Meeting 2010
Strasbourg (France), 2010

A. VILALTA-CLEMENTE, G. R. MUTTA, M. MORALES, J.L. DOUALAN, J. GRANDAL, M. A. SÁNCHEZ-GARCÍA, F. CALLE, E. VALCHEVA, K. KIRILOV AND P. RUTERANA
"Structural Study of InN layer with compressive strain"
E-MRS, Symposium G: Physics and applications of novel gain materials based on III-V-N compounds
Strasbourg (France), 2010

K. YAMAMOTO, A. HIERRO, E. MUÑOZ, A. NAKAMURA, J. TEMMYO
"ZnCdO multiple-quantum-well green LEDs"
6th International Workshop on ZnO and Related Materials
Changchun (China), 2010

2011

D. ARAÚJO, M.P. VILLAR, J.G. RODRÍGUEZ, G.F. IRIARTE, O. A. WILLIAMS, F. CALLE
"TEM study of AlN/diamond structures for high frequency SAW resonators"
5th International Conference on New Diamond and Nano Carbons 2011
Kunibiki Messe, Matsue-city, Shimane (Japan) 2011

C. AROCA, P. COBOS, M. MAICAS, M.M. SANZ
"High resolution system for nanoparticles hyperthermia efficiency evaluation"
Asia International Magnetics Conference, InterMag 2011
Taipei (Taiwan), 2011

S.ALBERT, P. LEFEBVRE, J. GRANDAL, M. A. SANCHEZ-GARCIA, E. CALLEJA
"Emission control of InGaN nanocolumns with growth temperature"
9th International Conference on Nitride Semiconductors (ICNS)
Glasgow (UK), 2011

S. ALBERT, A. BENGOECHEA-ENCABO, F. BARBAGNI, P. LEFEBVRE, M. A.SANCHEZ-GARCIA, E. CALLEJA, E. LUNA, A. TRAMPERT
"Selective area growth of GaN nanocolumns by rf-plasma-assisted MBE at low temperature and under nitrogen-rich conditions"
9th International Conference on Nitride Semiconductors (ICNS)
Glasgow (UK), 2011

F.J. APARICIO, M. HOLGADO, A. BORRAS, M. ALCAIRE, A. GRIOL, C.A. BARRIOS, R. CASQUEL, F.J. SANZA, H. SOHLSTRÖM, M. ANTELIUS, A.R. GONZALEZ-ELIPE, A. BARRANCO
"Photofunctional Organic Nanocomposites Deposited by Remote Plasma Assisted Vacuum Deposition for Photonic Environmental Sensing Application"
European Material Research Society (E-MRS)
Estrasburgo (France), 2011

D. ARAÚJO, M.P. VILLAR, J.G. RODRÍGUEZ, G.F. IRIARTE, O. A. WILLIAMS, F. CALLE
"TEM study of AlN/diamond structures for high frequency SAW resonators"
5th International Conference on New Diamond and Nano Carbons 2011
Sendai International Center (Japan), 2011

F. BARBAGINI, A. BENGOENCHEA-ENCABO, S. ALBERT, J. MARTINEZ, M. A. SANCHEZ-GARCIA, E. CALLEJA
"Substrate nanopatterning by e-beam lithography to growth ordered arrays of III-nitride nanodetectors, white light emitters, and solar cells, Marie Curie Researchers Symposium"
"SCIENCE – Passion, Mission, Responsibilities", Polish Presidency of the EU Council
Warsaw (Poland), 2011

F. BARBAGINI, J. MARTINEZ, A. BENGOENCHEA-ENCABO, S. ALBERT, M. A. SANCHEZ-GARCIA, E. CALLEJA,
"E-beam nanopatterning for the selective area growth of III-V nitride nanorods"
37th International Conference on Micro and Nano Engineering
Berlin (Germany), 2011

C.A. BARRIOS, P. YURRITA, S. CARRASCO, M. FRANCESCA, F. NAVARRO-VILLOSLADA, M.C. MORENO-BONDI
"Development and Characterization of Biomimetic Polymers for Optical Waveguide Devices"
SIMC XVI (2011)
Estocolmo (Sweden), 2011

A. BENGOECHEA-ENCABO, S. ALBERT, F. BARBAGINI, P. LEFEBVRE, M. A. SANCHEZ-GARCIA, E. CALLEJA, E. LUNA, A. TRAMPERT
"Control of the morphology on selective area growth of GaN nanocolumns by rf-plasma-assisted MBE"
9th International Conference on Nitride Semiconductors (ICNS)
Glasgow (UK), 2011

A. BENGOECHEA-ENCABO, F. BARBAGINI, S. FERNANDEZ-GARRIDO, J. GRANDAL, J. RISTIC, M.A. SÁNCHEZ-GARCÍA, E. CALLEJA, U.JAHN, E. LUNA, A. TRAMPERT
"Understanding the selective area growth of GaN nanocolumns by MBE using Ti nanomasks"
40th "Jaszowiec" International School and Conference on the Physics of Semiconductors
Krynica-Zdrój (Poland), 2011

A. BENGOECHEA-ENCABO, F. BARBAGINI, S. FERNANDEZ-GARRIDO, J. GRANDAL, J. RISTIC, M.A. SANCHEZ-GARCIA, E. CALLEJA, U. JAHN, E. LUNA, A. TRAMPERT
"Understanding of the nucleation and growth of ordered GaN nanocolumns by MBE on GaN templates"
11th International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN 2011)
Berlin (Germany), 2011

A. BOSCÁ, D. LÓPEZ-ROMERO, S. ALVAREZ. A. DE ANDRÉS, F. CALLE
"Carbon graphitization on top of SiO2"
20th European Workshop on Heterostructures Technology
Lille (France), 2011

T. BRAZZINI, A. DE PRADO, J. GRANDAL, A. DAS, E. MONROY, F. CALLE
"InN-based MIS rectification device"
E-Material Research Society, Symp H. InN and related alloys
Nice (France), 2011

T. BRAZZINI, S.ALBERT, J. GRANDAL, M.A. SÁNCHEZ-GARCÍA, F. CALLE
"InN/GaN heterojunction electrical behaviour"
9th International Conference on Nitride Semiconductors (ICNS)
Glasgow (UK), 2011

E. CALLEJA, A. BENGOECHEA-ENCABO, S. ALBERT, M.A. SÁNCHEZ-GARCÍA, F. BARBAGINI, E. LUNA, A. TRAMPERT, U. JAHN. P. LEFEBVRE
"Plasma-assisted MBE growth of III-N nanorods: applications to optoelectronic devices and photovoltaics"
11th International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN 2011)
Berlin (Germany), 2011

E. CALLEJA, A. BENGOECHEA-ENCABO, F. BARBAGINI, S. FERNANDEZ-GARRIDO, J. RISTIC, M.A. SANCHEZ-GARCIA, U. JAHN, E. LUNA, A. TRAMPERT
"Understanding the selective area nucleation and growth of GaN nanocolumns by MBE using Ti nanomasks"
2011 German-Japanese-Spanish Joint Workshop on Frontier Photonic and Electronic Materials and Devices
Granada (Spain), 2011

J. CAMARERO, C.RODRIGO, P. PERNA, M. MUNOZ, J.L PRIETO, A. BOLLERO, J.L.F CUNADO, M. ROMERA, J. AKERMAN, E. JIMENEZ, N. MIKUSZEIT, R. MIRANDA
"Simultaneous study of magnetization reversal and magneto-resistive properties in spin-valve structures"
11th International Conference on Atomically Controlled Surfaces, Interfaces and Nanostructures
San Petersburg (Russia), 2011

R. CUERDO, I. SARASOLA, P. GARCIA de ACILU, J. NAVARRETE, M. CAFIADAS, C. OLLER, M. CELA, P. RATO MENDES
"Evaluation of a PET Prototype using LYSO:Ce Monolithic Detector Blocks"
Nuclear Science Symposium and Medical Imaging Conference
Valencia (Spain), 2011

M.P. CHAUVAT, B. LACROIX, A. VILALTA CLEMENTE, G.R. MUTTA, P. RUTERANA, J. GRANDAL, S. ALBERT, M.A SÁNCHEZ-GARCÍA, E. CALLEJA
"The microstructure of InN/InGaN heterostructures and quantum wells grown by MBE"
E-MRS Spring Meeting, Symposium H on Indium Nitride and Related Compounds
Nice (France), 2011

A. ELJARRAT, Z. GACEVIC, S. FERNANDEZ-GARRIDO, E. CALLEJA, C. MAGEN, S. ESTRADE, F. PEIRO
"Optical and structural properties of InAlN/GaN Bragg reflectors examined by transmission electron microscopy and electron energy loss spectroscopy"
Microscopy at the Frontiers of Science 2011
Aveiro (Portugal), 2011

K. FOTEINOPOULOU, N. C. KARAYIANNIS, M. LASO, M. KRÖGER
"Scaling dependence of topological hindrance on concentration: Entanglements and knots in model polymer systems"
Rheology Trends: from nano to macro systems, Editors: M.T. Cidade, I. M. N. Sousa, J. M. Franco, ISBN: 978-972-8669-50-8, p. 243.
Ibereo 2011, CENIMAT, FCT/UNL
Caparica (Portugal), 2011

K. FOTEINOPOULOU, M. LASO
"Modeling the effect of cell- associated polymeric fluid layers on force spectroscopy measurements"
Rheology Trends: from nano to macro systems, Editors: M.T. Cidade, I. M. N. Sousa, J. M. Franco, ISBN: 978-972-8669-50-8, Lisboa 2011, p. 87.
Ibereo 2011, CENIMAT, FCT/UNL
Caparica (Portugal), 2011

Ž. GAČEVIĆ, S. FERNÁNDEZ-GARRIDO, E. CALLEJA, D. HOSSEINI, S. ESTRADE, F. PEIRÓ
"Structural properties of InAIN single layers nearly latice-matched to GaN grown by plasma assisted molecular beam epitaxy"
European workshop on Molecular Beam Epitaxy 2011
L' Alpe D'Huez (France), 2011

Ž. GAČEVIĆ, P. LEFEBVRE, F. BERTRAM, G. SCHMIDT, P. VEIT, J. CHRISTEN, E. CALLEJA
"Growth and characterization of InGaN/GaN quantum dots for violet/blue applications"
International Conference on Nitride Semiconductors 2011
Glasgow (UK), 2011

E. GUR, G. TABARES, A. AREHART, J.M. CHAUVEAU, A. HIERRO, S. RINGEL
"High Level of Mg Alloying Effects on the Deep Level Defects in MgxZn1-xO"
AVS 58th International Symposium & Exhibition
Nashville, Tennessee (USA), 2011

A. HIERRO,G. TABARES, CH. DE PARIS, CH. MORHAIN, J-M CHAUVEAU
"ZnO/ZnMgO QW Schottky photodiodes sensitive to light polarization"
Photonics West Exhibition. The Moscone Center
San Francisco, California (USA), 2011

A. HIERRO, M. MONTES, M. MORAL, J.M. ULLOA, A. GUZMÁN
"Near infrared high efficiency InAs/GaAsSb QDLEDs: band alignment and carrier recombination mechanisms"
European Molecular Beam Epitaxy workshop
Alpe D'Huez (France), 2011

A. HIERRO, G. TABARES, C. DEPARIS, C. MORHAIN AND J.-M. CHAUVEAU
"ZnO/ZnMgO QW Schottky photodiodes sensitive to light polarization"
SPIE Potonics West
San Francisco (USA), 2011

D. HOSSEINI, S. ESTRADA, Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, E CALLEJA, F. PEIRÓ
"Transmission Electron Microscopy and Electron Energy Loss Spectroscopy investigations of InAlN/GaN Bragg reflectors grown by plasma-assisted Molecular Beam Epitaxy"
8th Spanish Conference on Electron Devices, CDE'2011
Palma de Mallorca (Spain), 2011

D. HOSSEINI S. CONESA J.M. REBLED S. ESTRADE C. MAGEN, ZARKO GACEVIC S. FERNANDEZ GARRIDO, E.CALLEJA, F. PEIRÓ
"STEM-HAADF-EELS and HRTEM assessment of cubic-hexagonal transitions and In-enrichment in InAlN/GaN Bragg reflectors grown by plasma-assisted Molecular Beam Epitaxy"
Microscopy of Semiconducting Materials 2011
Cambridge (UK), 2011

G.F. IRIARTE, J.G. RODRIGUEZ-MADRID, R. RO, R. LEE, O.A. WILLIAMS, D. ARAUJO, M.P. VILLAR, F. CALLE
"Fabrication of high frequency SAW resonators using AlN/Diamond/Si technology"
IEEE Ultrasonics Symposium
Orlando (USA), 2011

P. LEFEBVRE, M.A. SANCHEZ-GARCIA, E.CALLEJA
"MBE growth and characterization of InGaN nanocolumns on Silicon substrates"
European Materials Research Society Spring Meeting
Nice (France), 2011

M. LOPEZ-PONCE, A. HIERRO, J. M. ULLOA, E. MUÑOZ, A. NAKAMURA, J. TEMMYO, K. YAMAMOTO
"Processing and adsorption control in ZnO single nanowire photodetectors"
8th Spanish Conference on Electron Devices, CDE'2011
Palma de Mallorca (Spain), 2011

M. LOPEZ-PONCE, A. HIERRO, J.M. ULLOA, P. LEFEBVRE, G. TABARES, E. MUÑOZ, K. YAMAMOTO, A. NAKAMURA, J. TEMMYO.
"Analysis of the photoluminescence of zn1-xcdxo nanowires under thermal annealing"
SJNano 2011 (I Bilateral Spanish-Japanese School/Workshop on Nanotechnology and New Materials to face Environmental Challenges), Toledo (Spain), 2011

M. LOPEZ-PONCE, A. HIERRO, J. M. ULLOA, E. MUÑOZ, K.YAMAMOTO, A. NAKAMURA, J. TEMMYO
"Processing and adsorption control in Zn1-x CdxO single nanowire photodetectors"
8th Spanish Conference on Electron Devices, CDE'2011
Mallorca (Spain), 2011

E. LUNA , R. HEY, A. GUZMÁN, A. TRAMPERT
"Comparison of interface properties in two-dimensional heterostructures grown layer-by-layer or by step flow"
16th European Molecular Beam Epitaxy Workshop
Alpe d'Huez (France), 2011

A. LLAVONA, V. DE MANUEL, M.C. SÁNCHEZ, L. PÉREZ
"Composition profile in electrodeposited Ni Fe nanowires"
18th International Symposium on Metastable, Amorphous and Nanostructured Materials (ISMANAM 2011) (2011).
Gijón (Spain), 2011

J. MARTINEZ, F. BARBAGINI, A. BENGOENCHEA-ENCABO, S. ALBERT, M. A. SANCHEZ-GARCIA, E. CALLEJA
"Fabrication of GaN nanorods by focused ion beam"
3th International Conference in Micro and Nano Engineering
Berlín (Germany), 2011

S. MARTÍN-HORCAJO, M.J. TADJER, M.A. DI FORTE POISSON, R. CUERDO, F. CALLE
"High Temperature Pulsed and DC Performance of AlInN/GaN HEMTs"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

S. MARTÍN-HORCAJO, M. J. TADJER, R. CUERDO, E. SILLERO, M. F. ROMERO, F. CALLE
"Method of Channel Temperature and Thermal Resistance Extraction in AlGaN/GaN HEMTs"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

S. MARTÍN-HORCAJO, M. TADJER, F. ROMERO, R. CUERDO, F. CALLE
"Fabrication and characterization at high temperature of AlGaN/GaN enhancement HEMTs"
8th Spanish Conference on Electron Devices, CDE'2011
Palma de Mallorca (Spain), 2011

M.J. MILLA, Á. GUZMÁN, J.M. ULLOA, A. HIERRO
"MBE growth approaches for improving Sb-based In0.5Ga0.5As(Sb)/GaAs QDs"
European Molecular Beam Epitaxy Workshop
Alpe D'Huez (France), 2011

M.J. MILLA, J.M. ULLOA, A. HIERRO, A. GUZMÁN
"Gas sensor based on room temperature optical properties of Surface QDs"
19th European Workshop on Heterostructure Technology (HETECH 2011)
Lille (France), 2011

M.J. MILLA, Á. GUZMÁN, J.M. ULLOA, A. HIERRO
"Room temperature photoluminescence of InGaAs Surface Quantum Dots"
Quantum Dots France 2011
Toulosse (France), 2011

M.C. MORENO-BONDI, G. ORELLANA, F. NAVARRO, A.B. DESCALZO, E. BENITO-PEÑA, J. URRACA, J. ZDUNEK, S. CARRASCO, C. A. BARRIOS
"Potencial Analítico de los Polímeros de Impronta Molecular (MIPs) como Elementos de Reconocimiento Biomimético"
XXXIII Reunión Bienal de la Real Sociedad Española de Química
Valencia (Spain), 2011

E. MUÑOZ, A. NAVARRO, J. PEREIRO, A. REDONDO-CUBERO
"InGaN photodetectors and applications in biophotonics"
35th Workshop on compound semiconductor devices and integrated circuits (WOCSDICE 2011)
Catania (Italy), 2011

G.R. MUTTA, B. GUILLET, L. MECHIN, A. VILALTA-CLEMENTE, J. GRANDAL, M.A. SANCHEZ-GARCIA, S. MARTIN-HORCAJO, F. CALLE, P. RUTERANA, J.-M. ROUTOURE
"Evidence of charge carrier number fluctuations in InN thin films?"
International Conference on Noise and Fluctuations
Toronto (USA), 2011

G.R. MUTTA, J.M. ROUTOURE, B. GUILLET, L. MÉCHIN, M. A. SÁNCHEZ-GARCÍA, F. CALLE, P. RUTERANA
"Evidence of charge carrier number fluctuations by low frequency noise measurements in MBE grown Indium Nitride layers"
E-Material Research Society, Symp H. InN and related alloys
Nice (France), 2011

F.J. ORTEGA, M.J. BAÑULS, F.J. SANZA, R. CASQUEL, M.F. LAGUNA, M. HOLGADO, D. LÓPEZ-ROMERO, C.A. BARRIOS, A. MAQUIEIRA,, R. PUCHADES
"Estructuras poliméricas de bajo coste basadas en micro-platos para biosensado sin marcaje"
V Workshop on Molecular Recognition
Valencia (Spain), 2011

F.J. ORTEGA, M.J. BAÑULS, F.J. SANZA, R. CASQUEL, M.F. LAGUNA, M. HOLGADO, D. LÓPEZ-ROMERO, C.A. BARRIOS, A. MAQUIEIRA, R. PUCHADES
"Label-free optical biosensing of gestrinone doping hormone employing su-8 nano-pillars"
13as Jornadas de Análisis Instrumental
Barcelona (Spain), 2011

F.J. ORTEGA, M.J. BAÑULS, F.J. SANZA, D. LÓPEZ-ROMERO, R. CASQUEL, M. HOLGADO, M.F. LAGUNA, C.A. BARRIOS, A. MAQUIEIRA, R. PUCHADES
"Nanopilares de matriz polimérica sobre substrato transparente para biosensado óptico sin marcaje"
V Workshop Nanociencia y Nanotecnología Analíticas 2011
Toledo (Spain), 2011

J. PEDRÓS, L. GARCIA-GANCEDO, C.J.B. FORD, C.H. BARNES, J. GRIFFITHS, G.A. JONES, A.J. FLEWITT, F. CALLE
"High frequency high-order Rayleigh modes in ZnO/GaAs"
IEEE Frequency Control Symposium
San Francisco (USA), 2011

J. PEDRÓS, R.P.G. MCNEIL, C.J.B. FORD, J. GRIFFITHS, G.A.C. JONES, Z. BOUGRIUOA, F. CALLE
"Acoustic charge transport through 1D constrictions in 2DEG AlGaN/GaN heterostructures"
International Conference on Electronic Properties of 2 Dimensional Systems 19 (EP2DS-19)
Florida (USA), 2011

P. PERNA, C. RODRIGO, M. MUÑOZ, J.L. PRIETO, A. BOLLERO, J.F. CUÑADO, M. ROMERA, J. AKERMAN, E. JIMENEZ, N. MIKUSZEIT, V. CROS, J. CAMARERO, R. MIRANDA
"Simultaneous study of magnetization reversal and magnetoresistive properties in spin-valve structures"
56th Annual Conference of MMM 2011 (Magnetism & Magnetic Materials)
Scottsdale, AZ (U.S.A.), 2011

J.L. PRIETO, M. MUÑOZ, E. MARTINEZ
"Nucleation of a magnetic domain wall by a current pulse and its application to the structural characterization of the ferromagnetic nanowire"
Asia International Magnetics Conference, InterMag 2011
Taipei (Taiwan), 2011

R. PUCHADES, F.J. ORTEGA, M.J. BAÑULS, F.J. SANZA, M.F. LAGUNA, R. CASQUEL, M. HOLGADO, D. LÓPEZ-ROMERO, C.A. BARRIOS, A. MAQUIEIRA
"Desarrollo de un nuevo material polimérico biotinilado para biosensado"
XXXIII Reunión Bienal de la Real Sociedad Española de Qumica Proceedings de la conferencia
Valencia (Spain), 2011

J. RAMÍREZ, N.C. KARAYIANNIS
"Rheology of linear monodisperse polyethylene melts from atomistic Molecular Dynamics simulations"
Rheology Trends: from nano to macro systems, Editors: M.T. Cidade, I. M. N. Sousa, J. M. Franco, ISBN: 978-972-8669-50-8, Lisboa 2011, p. 87.
Ibereo 2011, CENIMAT, FCT/UNL
Caparica (Portugal), 2011

R. RANCHAL, V. GUTIÉRREZ-DÍEZ, V. GONZÁLEZ-MARTÍN
"Magnetic properties of nanostructured systems based on TbFe2"
International Symposium on Metastable, Amorphous and Nanostructured Materials (ISMANAM) 2011
Gijón (Spain), 2011

M. ROMERA, M. MUNOZ, J. MICHALIK, J. DE TERESA, J. PRIETO
"Study of the magnetic properties of Gd in a Fe/Gd/Fe trilayer by means of transport measurements on a double spin valve"
Asia International Magnetics Conference, InterMag 2011, 2011
Taipei (Taiwan), 2011

A. REDONDO-CUBERO, J. PEREIRO, K. LORENZ, N. FRANCO, J. GRANDAL, E. ALVES, E. MUÑOZ
"Relaxation, crystal quality and phase separation in InGaN epilayers grown at intermediate contents (x~0.5)"
9th International Conference on Nitride Semiconductors (ICNS 2011)
Glasgow (UK), 2011

A. REDONDO-CUBERO, M.F. ROMERO, M. PERONI, C. LANZIERI, A. CETRONIO, E. MUÑOZ
"Controlled diffusion of Au/Ni/Al/Ti ohmic contacts in AlGaN/GaN HEMTs: limits for the barrier effect of Al"
9th International Conference on Nitride Semiconductors (ICNS 2011)
Glasgow (UK), 2011

D.F. REYES, D.L. SALES, R. GARGALLO-CABALLERO, J.M. ULLOA, A. HIERRO, A. GUZMÁN, R. GARCÍA, D. GONZÁLEZ
"Evaluation of the In desorption during the capping process of diluted nitride In(Ga)As quantum dots"
17th International Conference On Microscopy Of Semiconducting Materials 2011.
Book Series: Journal of Physics Conference Series, Volume: 326, Article Number: 012049
Cambridge (UK), 2011

D. F. REYES, D. L. SALES, D. GONZÁLEZ, J. M.ULLOA, M.MONTES, A. GUZMÁN, A. HIERRO
"Transmission electron microscopy characterization of InAs-GaAsSb(N) dots in well for 1.55 microns telecommunications"
Microscopy at the Frontiers of Science
Aveiro, Portugal, (2011)

J.G. RODRIGUEZ-MADRID, G.F. IRIARTE, O. WILLIAMS, W. MÜLLER-SEBER, F. CALLE
"Sputtering of AlN on micro and nanocrystalline diamond for high frequency SAW devices"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

J.G. RODRÍGUEZ, G. FUENTES, M.P. MARTIN, D. ARAÚJO, O. WILLIAMS, F. CALLE
"Sputter optimization of AlN on diamond substrates for high frequency SAW resonators"
8th Spanish Conference on Electron Devices, CDE'2011
Palma de Mallorca (Spain), 2011

M.F. ROMERO, M.J. UREN, A. JIMÉNEZ, C. DUA, M.J. TADJER, R. CUERDO, F. CALLE, E. MUÑOZ
"Thermal effects in Ni/Au and Mo/Au gate metallization AlGaN/GaN HEMT's reliability"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

M.F. ROMERO, A. JIMÉNEZ, F. GONZÁLEZ-POSADA, S. MARTÍN, F. CALLE, E. MUÑOZ
"Impact of N2 plasma power and duration on AlGaN/GaN HEMT"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

M.A. SANCHEZ-GARCIA, A. BENGOECHEA-ENCABO, S. ALBERT, F. BARBAGINI, E. CALLEJA, U. JAHN, E. LUNA, A. TRAMPERT
"Understanding the selective area nucleation and growth of GaN Nanocolumns by MBE using Ti nanomasks"
5th French GDR "Semiconductors Nanowires and Nanotubes"
Porquerolles (France), 2011

AR. STACEL, W.M. LINHART, J. PEREIRO, J. GRANDAL, M.A. SÁNCHEZ-GARCÍA, E. MUÑOZ, E. CALLEJA, W.J. SCHAFF, T. D.VEAL
"Electrochemical capacitance voltage profiling of transition from surface electron depletion to accumulation with increasing In-content in InGaN alloys"
E-MRS Spring Meeting, Symposium H on Indium Nitride and Related Compounds
Nice (France), 2011

G. TABARES, A. AREHART, J.M. CHAUVEAU, A. HIERRO, S.A. RINGEL
"High Level of Mg Alloying Effects on the Deep Level Defects in MgxZn1-xO"
53rd Annual Electronic Materials Conference
University of California Santa Bárbara, CA (USA), 2011

G. TABARES, A. AREHART, J.M. CHAUVEAU,, A. HIERRO, S.A. RINGEL
"ZnMgO-based photodetectors for short wavelength and light polarization detection"
53rd Annual Electronic Materials Conference
University of California Santa Bárbara, CA (USA), 2011

M. J. TADJER, T. J. ANDERSON, K. D. HOBART, L. O. NYAKITI, B. PATE, F. CALLE
"Cryogenic behaviour of nanocrystalline diamond and epitaxial graphene Schottky contacts to 4H-SiC"
22nd European Conf Diamond, Diamond-Like Materials, Carbon Nanotubes, and Nitrides (Diamond 2011)
Garmisch (Germany), 2011
M.J. TADJER, S. MARTIN-HORCAJO, T.J. ANDERSON, M.S. SILLER, H. BEHMENBURG, C. GIESEN, M. HEUKEN, F. CALLE
"2D Channel Modulation of AlInN/GaN HEMTs Using a Selective Recess Etch"
9th International Conference on Nitride Semiconductors
Glasgow (UK), 2011

A. VILALTA-CLEMENTE, M. MORALES, J. GRANDAL, S. ALBERT, M.A. SÁNCHEZ-GARCÍA, F. CALLE, P. RUTERANA
"X-ray diffraction and transmission electron microscopy analysis of threading dislocations in MBE grown InN layers"
E-Material Research Society, Symp H. InN and related alloys
Nice (UK), 2011

J. M. ULLOA, M. MONTES, K. YAMAMOTO, A. GUZMAN, A. HIERRO, M. BOZKURT, P. M. KOENRAAD, D. FERNANDEZ, D. GONZALEZ, D. L. SALES
"Size, strain, and band offset engineering in GaAs(Sb)(N)-capped InAs quantum dots for 1.3 - 1.55 µm LEDs and LDs"
SPIE Photonics West. Quantum Dots and Nanostructures : Synthesis, Characterization and modeling VIII. Book Series: Proceedings of SPIE, vol 7947, Article Number: 79470T
San Francisco (USA), 2011

J.M. ULLOA, M. MONTES, K. YAMAMOTO, A. GUZMAN, A. HIERRO, J.M. LLORENS, M. BOZKURT, P.M. KOENRAAD, D. FERNANDEZ, D. GONZALEZ, D.L. SALES
"Modified optical properties of GaAs(Sb)(N)-capped InAs/GaAs quantum dots"
Quantum Dot Conference, 2011
Toulouse (France), 2011

J.M. ULLOA, M. DEL MORAL, A. GUZMAN, A. HIERRO, M. BOZKURT, P.M. KOENRAAD
"Analysis of the modified optical properties of GaAs1-xSbx-capped InAs/GaAs quantum dots"
European Materials Research Society Spring Meeting 2011
Nice (France), 2011

J.M. ULLOA, M. MONTES, K. YAMAMOTO, A. GUZMAN, A. HIERRO, M. BOZ
"Tuning the size, strain and band offsets of InAs/GaAs quantum dots through a thin GaAs(Sb)(N) capping layer"
European Molecular Beam Epitaxy Workshop
Alpe D'Huez (France), 2011

K. YAMAMOTO, J. M. ULLOA, A. HIERRO, A. GUZMÁN
"Synthesis and characterization of GaAsSb-capped InAs-based QDIPs"
38th International Symposium on Compound Semiconductors (ISCS)
Berlin (Germany), 2011

K. YAMAMOTO, J. M. ULLOA, A. HIERRO, A. GUZMÁN
"Absorption analysis of GaAsSb-capped InAs/GaAs quantum-dot infrared photodetectors"
Quantum Dot France
Toulouse (France), 2011

K. YAMAMOTO, J. M. ULLOA, A. GUZMÁN, A. HIERRO
"Mid-infrared photodetectors based on GaAsSb-capped InAs quantum dots"
Spanish-Japanese Workshop 2011
Toledo (Spain), 2011

LL. YEDRA, S. ESTRADÉ, J.M. REBLED, Z. GACEVIC, S. FERNÁNDEZ-GARRIDO, E. CALLEJA, H. HEIDARI, B. GORIS, S. BALS, F. PEIRÓ
"Tomography of multilayered materials for optoelectronic applications"
MRS Fall Meeting 2011
Boston (USA), 2011

2012

M. ABUIN, B. SANTOS, A. MASCARAQUE, M. MAICAS, L. PEREZ, E. MIRALLES, A. QUESADA, A. T. N´DIAYE, A. K. SCHMID, J. DE LA FIGUERA
"Magnetic domain structure of Co ultra-thin islands on Ru"
13Th Trends in Nanotechnology International Conference (TNT2012)**"**
Madrid (Spain), 2012

S. ALBERT, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCÍA, E. CALLEJA, A. TRAMPERT , U. JAHN
"Phosphor-free white light emission from ordered InGaN/GaN nanocolumnar structures"
ISSLED 2012
Berlin (Germany), 2012

S. ALBERT , A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCÍA, E. CALLEJA, A. TRAMPERT, U. JAHN
"Growth and characterization of ordered InGaN/GaN nanocolumnar structures on GaN/sapphire and Si (111) substrates"
IWN 2012
Sapporo (Japan), 2012

T.J. ANDERSON, K.D. HOBART, M.J. TADJER, T.I. FEYGELSON, E.A. IMHOFF, D.J. MEYER, D.S. KATZER, J.K. HITE, F.J. KUB, B.B. PATE, S.C. BINARI, AND C.R. EDDY, JR.
"Improved GaN-based HEMT Performance by Nanocrystalline Diamond Capping"
Device Research Conference
Pennsylvania (USA), 2012

T. J. ANDERSON, M. J. TADJER, K. D. HOBART, T. I. FEYGELSON, J. D. CALDWELL, M. A. MASTRO, J. K. HITE, C. R. EDDY, JR., F. J. KUB, B. B. PATE
"ProFIling the Temperature Distribution in AlGaN/GaN HEMTs with Nanocrystalline Diamond Heat Spreading Layers"
CS MANTECH 2012
Boston (USA), 2012

F. BARBAGINI, A. BENGOECHEA-ENCABO, S. ALBERT, M LOPEZ PONCE, MA. SANCHEZ-GARCIA, E. CALLEJA
"Electrical characterization of single GaN/InGaN nanorods grown by selective-area MBE"
IWN 2012
Sapporo (Japan), 2012

A. BENGOECHEA-ENCABO, S. ALBERT. F. BARBAGINI, MA SANCHEZ-GARCIA, E. CALLEJA, UWE JAHN, A. TRAMPERT, G. NATAF, P DE MIERRY, J.ZUÑIGA-PEREZ
"Selective area growth of GaN/InGaN nanocolumnar heterostructures on polar, semipolar and non-polar substrates"
ISSLED 2012
Berlin (Germany), 2012

A. BENGOECHEA-ENCABO. S. ALBERT. F. BARBAGINI, MA SANCHEZ-GARCIA, E. CALLEJA, UWE JAHN, A. TRAMPERT, G. NATAF, P DE MIERRY, J.ZUÑIGA-PEREZ
"Influence of substrate orientation on the morphology and optical properties of selective area growth GaN nanocolumns and InGaN quantum disks"
IWN 2012
Sapporo (Japan), 2012

A. BOSCÁ, D. LÓPEZ-ROMERO, J. MARTÍNEZ, J.A. GARRIDO, T. PALACIOS, F. CALLE
"Ambient p-doping of CVD graphene"
Graphene 2012
Brussels (Belgium), 2012

A. BOSCA, F. CALLE
"Physical model for electrical measurements in graphene"
21th European Workshop on Heterostructures Technology
Barcelona (Spain), 2012

A. BOSCA, D. LOPEZ-ROMERO, S. ALVAREZ. A. DE ANDRES, J. MARTINEZ, F. CALLE
"Graphene-like layers obtained from PMMA"
21th European Workshop on Heterostructures Technology
Barcelona (Spain), 2012

T. BRAZZINI, M. J. TADJER, Z. GACEVIC, S. PANDEY, A. CAVALLINI, H. BEHMEN-BURG, C. GIESEN, M. HEUKEN, F. CALLE
"Structural characterization of wet-etched quaternary InAlGaN barrier HEMT structures"
International Workshop on Nitride Semiconductors
Sapporo (Japan), 2012

T. BRAZZINI, A. BENGOECHEA-ENCABO, M.A. SANCHEZ-GARCIA, F. CALLE
"Investigation of Al1−xInxN barrier ISFET structures with GaN capping on silicon substrates for pH detection"
International Workshop on Nitride Semiconductors
Sapporo (Japan), 2012

T. BRAZZINI, S. PANDEY, M.F. ROMERO, A. CAVALLINI, M. FENEBERG, R. GOLDHAHN, H. BEHMENBURG, C. GIESEN, M. HEUKEN, F. CALLE
"Photocurrent analysis of MSM InAlGaN/GaN heterostructure photodetectors"
International Workshop on Nitride Semiconductors
Sapporo (Japan), 2012

F. CALLE, JG. RODRIGUEZ MADRID, G. F. IRIARTE, J. PEDROS, O. WILLIAMS, M. P. VILLAR, D. ARAUJO, R. RO, R.LEE
"High Frequency AlN/Diamond SAW devices"
EXMATEC 2012
Porquerolles (France), 2012

F. CALLE, T.A. PALACIOS
"Nanotechnology for high frequency communications: nitrides and graphene"
Trends in Nanotechnology, TNT 2012. September 10-14, 2012.
Sevilla (Spain), 2012

V. CANALEJAS-TEJERO, S. CARRASCO, F. NAVARRO-VILLOSLADA, M.C. CAPEL-SANCHEZ, J.L. GARCIA FIERRO, M.C. MORENO-BONDI, C.A. BARRIOS
"Ultrasensitive Non-Chemically Amplified Negative-Tone Electron Beam Lithography Resist"
Trends on Nanotechnology (TNT) 2012
Madrid (Spain), 2012

M. CURRIE, J. CALDWELL, F. BEZARES, J. ROBINSON, T. ANDERSON, H. CHUN, AND M. J. TADJER
"Pulsed Optical Damage of Graphene"
Electronic Materials Conference
Pennsylvania (USA), 2012

F. A. I. CHAQMAQCHEE, N. BALKAN, J. M. ULLOA, M. HUGUES, M. HOPKINSON
"Top-Hat HELLISH (THH)-VCSOA based on a light emitting and an absorbing for 1.3 µm wavelength operation"
International Conference on Superlattices, Nanostructures and Nanodevices (ICSNN)
Dresden (Germany), 2012

F. A. I. CHAQMAQCHEE, N. BALKAN, J. M. ULLOA, M. HUGUES, M. HOPKINSON
"T Top-Hat HELLISH (THH)-VCSOA based on a light emitting and an absorbing for 1.3 µm wavelength operation"
Site Controlled Epitaxy Workshop
Heraklion (Greece), 2012

A. ELJARRAT, L. LOPEZ-CONESA, Ž. GACEVIC, S. FERNANDEZ-GARRIDO, E. CALLEJA, C. MAGEN, S. ESTRADE, F. PEIRO
"EELS-HAADF combination for characterization of a new AlN/GaN DBRs growth method"
European Microscopy Congress 2012 (EMC 2012)
Manchester (UK), 2012

A. ELJARRAT, L. LOPEZ-CONESA, Ž. GAČEVIĆ, S. FERNANDEZ-GARRIDO, E. CALLEJA, C. MAGEN,S. ESTRADE, F. PEIRO
"AlN/GaN DBR layer low-loss EELS-HAADF compositional mapping"
Workshop on EELS in Materials Science 2012
Uppsala (Sweden), 2012

A. ELJARRAT, L. LÓPEZ-CONESA, Ž. GAČEVIĆ, S. FERNÁNDEZ-GARRIDO, E. CALLEJA, C. MAGÉN, S. ESTRADÉ, F. PEIRÓ
"EELS-HAADF spectrum imaging for characterization of (AlGa)N multilayer heterostructures"
Trends in Nanotechnology 2012 (TNT 2012)
Madrid (Spain), 2012

M. FENEBERG, M. RÖPPISCHER, C. COBET, N. ESSER, B. NEUSCHL, K. THONKE, M. BICKERMANN, M. F. ROMERO, R. GOLDHAHN
"Exciton fine structure related to spin-exchange interaction in AlN"
International Workshop on Nitride Semiconductors (IWN) 2012
Sapporo (Japan), 2012

T.I. FEYGELSON, M.J. TADJER, K.D. HOBART, B.B. PATE, T.J. ANDERSON, R.L. MYERS-WARD, D.K. GASKILL, C.R. EDDY, JR.
"Optimization of the growth of nanocrystalline diamond - 4H SiC heterojunctions"
International Conference on Diamond and Carbon Materials
Granada (Spain), 2012

K.FOTEINOPOULOU, N CH. KARAYIANNIS, M. LASO
"Entropy driven phase transition in dense packings of athermal chain molecules"
Trends in Nanotechnology (TNT) 2012
Madrid (Spain), 2012

Ž. GACEVIC, V. J. GOMEZ, N. GARCIA-LEPETIT, P.E.D. SOTO RODRIGUEZ, A. BENGOECHEA, S. FERNANDEZ-GARRIDO, R. NÖTZEL, E. CALLEJA
"A comprehensive diagram to grow (0001) InGaN alloys by PA-MBE"”
17th International Conference on Molecular Beam Epitaxy (MBE2012),
Nara (Japan), 2012

Ž. GACEVIC, G. ROSSBACH, M. GLAUSER, J. LEVRAT, G. COSENDEY, M.D. MARTIN, S. FERNANDEZ-GARRIDO, N. GARCIA LEPETIT, F. REVERET, J.-F. CARLIN, R. BUTTE, L. VIÑA, N. GRANDJEAN, E. CALLEJA
"Hybrid MBE/MOVPE grown III-nitride microcavity"
International Workshop on Nitride Semiconductors 2012
Sapporo (Japan), 2012

Ž. GACEVIC, V.J. GOMEZ, N. GARCIA LEPETIT, P.E.D. SOTO RODRIGUEZ, A. BENGOECHEA, S.FERNANDEZ-GARRIDO, R. NÖTZEL, E. CALLEJA
"A comprehensive diagram to grow (0001) InGaN alloys by molecular beam epitaxy"
International Workshop on Nitride Semiconductors 2012
Sapporo (Japan), 2012

L.K. GIL-HERRERA, P.MUÑOZ, J.LOPEZ-GEJO, C.PALACIO, E. MUÑOZ, G. ORELLANA
"Direct Grafting of Long-lived Luminescent Indicator Dyes to GaN Light-emitting Diodes (LEDs) for Chemical Microsensor Development"
XI Conference on Optical Chemical Sensors and Biosensors. (Europtrode XI)
Barcelona (Spain), 2012

V.J. GOMEZ, P.E.D. SOTO RODRIGUEZ, P. KUMAR, E. CALLEJA, R. NÖTZEL
"High In composition InGaN for InN quantum dot intermediate band solar cells"
International Workshop on Nitride Semiconductors (IWN2012)
Sapporo (Japan), 2012

F. HÖRICH, S. OSTERBURG, M. F. ROMERO, M. FENEBERG, T. SCHUPP, C. MIETZE, D. J. AS, R. GOLDHAHN
"Photoluminescence of cubic AlGaN layers"
76th Annual Conference of DPG and DPG-Spring Meeting 2012 of the Condensed Matter Section
Berlin (Germany), 2012

N.CH. KARAYIANNIS, K.FOTEINOPOULOU, M. LASO
"Entropy-driven crystallization in dense systems of athermal chain molecules"
International Workshop on Packing Problems
Dublin (Ireland), 2012

N.CH. KARAYIANNIS, J. RAMIREZ, A. LIKHTMAN
"Rheology of linear polyethylene melts from atomistic Molecular Dynamics simulations"
APS Meeting 2012
Boston (USA), 2012

M. LOPEZ-PONCE, A. HIERRO, J. M. ULLOA, P. LEFEBVRE, E. MUÑOZ, S. AGOURAM, V. MUÑOZ-SANJOSE, K. YAMAMOTO, A. NAKAMURA, J. TEMMYO
"Study of the effect of rapid thermal annealing in high Cd content Zn1-XCdXO nanowires grown by MOCVD"
International Workshop on ZnO
Nice (France), 2012

M. LOPEZ-PONCE, P. LEFEBVRE, C. BRIMONT, P. VALVIN, J. M. ULLOA, E. MUÑOZ, K. YAMAMOTO, A. NAKAMURA, J. TEMMYO, A. HIERRO
"Time-resolved Photoluminescence spectroscopy of Zn1-XCdXO nanowires"
International Workshop on ZnO
Nice (France), 2012

M. LOPEZ-PONCE, A. HIERRO, J. M. ULLOA, P. LEFEBVRE, E. MUÑOZ, S. AGOURAM, V. MUÑOZ-SANJOSE, K. YAMAMOTO, A. NAKAMURA, J. TEMMYO,
"Study of the effect of rapid thermal annealing in high Cd content Zn1-XCdXO nanowires grown by MOCVD"
International Workshop on ZnO
Nice (France), 2012

E. LUNA, A. GUZMAN, A. TRAMPERT, G. ÁLVAREZ
"Self-limited interface width of MBE-grown semiconductor heterointerfaces"
17th International Conference on Molecular Beam Epitaxy
Nara (Japan), 2012

J. MARTINEZ, A. BOSCA, A. BENGOENCHEA-ENCABO, S. ALBERT, M. A. SANCHEZ-GARCIA, E. CALLEJA, F. CALLE
"Graphene Electrodes For Nano-LEDs"
Graphene 2012
Brussels (Belgium), 2012

J. MARTINEZ, A. BOSCA, A. BENGOENCHEA-ENCABO, S. ALBERT, M. A. SANCHEZ-GARCIA, E. CALLEJA, F. CALLE
"NanoLEDs with graphene electrode"
Graphene 2012
Granada (Spain), 2012

M.D. MICHELENA, A.B. FERNANDEZ, M. MAICAS
"Application of finite element methods to the analysis of magnetic contamination around electronics in magnetic sensor devices"
2012 ESA Workshop on Aerospace EMC
Venecia (Italy), 2012

A.MINJ, M.F ROMERO, Ö. TUNA, CH. GIESEN, M. HEUKEN, S. PANDEY, D. CAVALCOLI, A. CAVALLINI, M. FENEBERG, R. GOLDHAHN
"Physical origin of emission in InGaN"
International Workshop on Nitride Semiconductors (IWN) 2012
Sapporo (Japan), 2012

B. NEUSCHL, M. FENEBERG, M. F. ROMERO, R. GOLDHAHN, Z. YANG, T. WUNDERER, J. XIE, S. MITA, A. RICE, R. COLLAZO, Z. SITAR, K. THONKE
"Optical studies on doped and nominally undoped AlN layers"
76th Annual Conference of DPG and DPG-Spring Meeting 2012 of the Condensed Matter Section
Berlin (Germany), 2012

G. ORELLANA, E. MUÑOZ, L. K. GIL-HERRERA, P. MUÑOZ, J. LÓPEZ-GEJO, C. PALACIO
"Integrated luminescent chemical microsensors based on GaN LEDs for security applications using smartphones"
Optical Materials and Biomaterials in Security and Defence Systems Technology IX
Proc. SPIE (The Society for Photo-Optical Engineers), Editors: R. Zamboni, F. Kajzar, A. A. Szep. ISBN 978-0-8194-2989-0. SPIE Security+Defence, Vol. 8545, Pág initial: 85450J-1, final: 85450J-9, Bellingham, WA (USA), 2012
Edinburgh, Escocia (UK), 2012

S.OSTERBURG, M. FENEBERG, M. F. ROMERO, B. GARKE, J. YAN, J. ZENG, J. WANG, AND R. GOLDHAHN
"Optical Investigation of Mg-doped AlGaN layers"
76th Annual Conference of DPG and DPG-Spring Meeting 2012 of the Condensed Matter Section
Berlin (Germany), 2012

S. PANDEY, A. MINJ, B. FRABONI, D. CAVALCOLI, A. CAVALLINI, T. BRAZZINI, F. CALLE
"Leakage Current and Schottky Barrier Height Variation in III-Nitride Heterostructures"
E-MRS, Simposium T "Physics and Applications of Novel gain materials based on Nitrogen and Bismuth Containing III-V Compound"
Strasbourg (France), 2012

P. PERNA, C. RODRIGO, M. MUÑOZ, J.L. PRIETO, A. BOLLERO, J. L. F. CUÑADO, D. MACCARIELLO, M. ROMERA, J. AKERMAN, E. JIMENEZ, N.I MIKUSZEIT, J.CAMARERO, R. MIRANDA
"Simultaneous study of magnetization reversal and magneto-resistive properties in spin-valve"
2012 MRS Spring Meeting
San Francisco, CA (USA), 2012

J. PEDROS, K. TEO, J. MARTINEZ, S. ÁLVAREZ, A. BOSCA, A. de ANDRES, F. CALLE
"Chemical vapour deposition of graphene on 3D metal foams"
European Workshop on Heterostructures Technology
Barcelona, (Spain), 2012

J. PEDROS, F. CALLE, J. GRAJAL, C.J.B. FORD
"Acoustoelectronics in AlGaN/GaN: from frequency control to single-electron transport applications"
36th Workshop Compound Semiconductors and Integrated Circuits, WOCSDICE.
Island of Porquerolles, (France), 2012

A. PEREZ, G.F. IRIARTE, F. CALLE
"Room temperature synthesis of AlN based piezoelectric microcantilevers"
21th European Workshop on Heterostructures Technology
Barcelona (Spain), 2012

P. PERNA, C. RODRIGO, D. MACCARIELLO, M. MUÑOZ, J.L. PRIETO, A. BOLLERO, J.L. F. CUÑADO, M. ROMERA, J. AKERMAN, N. MIKUSZEIT, J. CAMARERO, R. MIRANDA
"Features of the magnetization reversal mechanisms in the magnetoresistive response of magnetic multilayers"
MRS Spring Meeting 2012
San Francisco, CA (USA), 2012

P. PERNA, C. RODRIGO, D. MACCARIELLO, M. MUÑOZ, J.L. PRIETO, A. BOLLERO, J.L. F. CUÑADO, M. ROMERA, J. AKERMAN, N. MIKUSZEIT, J. CAMARERO, R. MIRANDA
"Features of the magnetization reversal mechanisms in the magnetoresistive response of magnetic multilayers"
JEMS 2012 Joint European Magnetic Symposia
Parma (Italy), 2012

J. RAMIREZ, N. CH. KARAYIANNIS, A. LIKHTMAN
"Rheology of linear polyethylene melts from atomistic Molecular Dynamics simulations"
ICR 2012 – XVIth International Congress on Rheology
Lisbon (Portugal), 2012

R. RANCHAL, C. AROCA
"Magnetic properties of TbFeGa thin Þ lms deposited by cosputtering"
JEMS 2012 Joint European Magnetic Symposia
Parma (Italy), 2012

A. REDONDO-CUBERO, M.D. YNSA, M.F. ROMERO, L.C. ALVES, E. MUÑOZ
"Formation of Au/Ti/Al/Ti ohmic contacts for AlGaN/GaN transistors: an ion beam study"
13th International Conference On Nuclear Microprobe Technology & Applications 2012
Lisbon (Portugal), 2012

A. REDONDO-CUBERO, M.F. ROMERO, L.C. ALVES, M. PERON, C. LANZIER, A. CETRONIO, E. ALVES, E. MUÑOZ
"In-depth diffusion and homogeneity of metallic contacts for GaN-based microdevices"
13th International Conference On Nuclear Microprobe Technology & Applications 2012
Lisbon (Portugal), 2012

D. F. REYES, D. L. SALES, J.M. ULLOA, A. GUZMAN, A.HIERRO, A. MAYORAL, D. GONZALEZ
"Impact of N on the structural properties of GaAsSbN-capped InAs QDs studied by advanced transmission electron microscopy techniques"
Fall European Materials Research Society Meeting (EMRS) 2012
Strasbourg (France), 2012

C. RODRIGO, P. PERNA, M. MUÑOZ, J. L. PRIETO, A. BOLLERO, J. L. F. CUÑADO, M.ROMERA, J. AKERMANN, E. JIMENEZ, N. MIKUSZEIT, V. CROS, J. CAMARERO, R. MIRANDA
"Simultaneous study of magnetization reversal and magnetoresistive properties in spin-valve structures"
3rd European Workshop on "Self-Organized Nanomagnets"
Guadarrama-Madrid (Spain), 2012

J.G. RODRIGUEZ-MADRID, G.F. IRIARTE, O.A.WILLIAMS, F. CALLE
"The influence of the diamond substrate surface on the SAW device performance"
New Diamond and Nano Carbon Conference
San Juan (Puerto Rico), 2012

J.G. RODRIGUEZ-MADRID, G.F. IRIARTE, O.A.WILLIAMS, F. CALLE
"High Precision Pressure Sensors Based on SAW Devices Fabricated on Diamond Substrates“
New Diamond and Nano Carbon Conference
San Juan (Puerto Rico), 2012

M. ROMERA, J. GROLLIER, V. CROS, S. COLLIN, T. DEVOLVER, M. MUÑOZ, J. L. PRIETO
"Substantial increase of the critical current on a Spin Transfer Nanopillar by adding an Fe/Gd/Fe trilayer"
13thTrends in Nanotechnology International Conference (TNT2012)
Madrid (Spain), 2012

M.F. ROMERO, M. FENEBERG, P. MOSER, C. BERGER, J. BLÄSING, A. DADGAR, A. KROST, E. SAKALAUSKAS, F. CALLE, R. GOLDHAHN
"Systematic optical characterization of two-dimensional electron gases in InAlN/GaN-based heterostructures with different In content"
International Workshop on Nitride Semiconductors
Sapporo (Japan), 2012

M. F. ROMERO, MARTIN FENEBERG, R. GOLDHAHN, P. MOSER, A. DADGAR, A. KROST
"Systematic optical characterization of InAlN/GaN heterostructures"
76th Annual Conference of DPG and DPG-Spring Meeting 2012 of the Condensed Matter Section
Berlin (Germany), 2012

P.E.D. SOTO RODRIGUEZ, P. KUMAR, V.J. GOMEZ, E. CALLEJA, R. NÖTZEL
"Growth of InN quantum dots on InGaN with high In composition"
17th International Conference on Molecular Beam Epitaxy (MBE2012)
Nara (Japan), 2012

G. TABARES, A. HIERRO, B. VINTER, J.-M. CHAUVEAU
"UV detection with a-ZnO/ZnMgO MQW Schottky and MSM photodetectors on a-ZnO"
International Workshop on ZnO
Nice (France), 2012

M.J. TADJER, T.J. ANDERSON, N. NEPAL, T. BRAZZINI, Ž. GACEVIC, S. MARTIN-HORCAJO, H. BEHMENBURG, C. GIESEN, M. HEUKEN, F. CALLE
"Electrical and Surface Characterization of Wet-etched InAlN/AlN/GaN HEMTs"
Electronic Materials Conference 2012, (EMC2012)
Pennsylvania State (USA), 2012

M.J. TADJER, T.J. ANDERSON, K.D. HOBART, T.I. FEYGELSON, J. D. CALDWELL, M. A. MASTRO, J. K. HITE, F. CALLE, F.J. KUB, B.B. PATE, C.R. EDDY, JR.
“Heat Spreading in III-Nitride HEMTs by Diamond Integration”
21st European Workshop on Heterostructure Technology
Barcelona (Spain), 2012

M.J. TADJER, A. CONSTANT, P. GODIGNON, S. M. HORCAJO, A. BOSCA, F. CALLE, M. BERTHOU, J. MILLAN
"Gate oxide stability of 4H-SiC MOSFETs under on/oFF-state bias-temperature stress""
9th European Conference on Silicon Carbide and Related Materials
Saint Petersburg, (Russia), 2012

M.J. TADJER, K.D. HOBART, T.J. ANDERSON, T.I. FEYGELSON, V.D. WHEELER, L.O. NYAKITI, R.D. MYERS-WARD, B.B. PATE, D.K. GASKILL, C.R. EDDY, JR., F.J. KUB, F. CALLE
"Thermionic and FIeld emission from nanocrystalline diamond and epitaxial graphene into epitaxial 4H-SiC"
International Conference on Diamond and Carbon Materials
Granada (Spain), 2012

M. J. TADJER, T. J. ANDERSON, N. NEPAL, T. BRAZZINI, Z. GACEVIC, S. MARTIN-HORCAJO, H. BEHMENBURG, C. GIESEN, M. HEUKEN, F. CALLE
"Electrical and Surface Characterization of Wet-etched InAlN/AlN/GaN HEMTs"
Electronic materials conference
Pennsylvania (USA), 2012

M. J. TADJER, T. J. ANDERSON, K. D. HOBART, L. O. NYAKITI, V. D. WHEELER, R. L. MYERS-WARD, D. K. GASKILL, C. R. EDDY, JR, F. J. KUB, F. CALLE
"Vertical Conduction Mechanism of Epitaxial Graphene Heterojunctions to 4H-SiC"
Electronic materials conference
Pennsylvania (USA), 2012

M.J. TADJER, T.J. ANDERSON, K.D. HOBART, T. I. FEYGELSON, A. WANG, C. R. EDDY, JR, F.J. KUB, F. CALLE
"Nanocrystalline diamond integration in III-Nitride HEMTs"
International Conference on Diamond and Carbon Materials
Granada (Spain), 2012

J. M. ULLOA, D. F. REYES, M. MONTES,D.L. SALES, D. GONZALEZ, A. GUZMAN, A. HIERRO
"Independent tuning of electron and hole confinement in InAs/GaAs quantum dots through a thin GaAsSbN capping layer"
Fall European Materials Research Society Meeting (EMRS) 2012
Strasbourg (France), 2012

J. M. ULLOA, D. F. REYES, D.L. SALES, D. GONZALEZ, M. MONTES, A. GUZMAN, A. HIERRO
"Broad band structure tunability of InAs/GaAs quantum dots with a thin GaAsSbN capping layer"
17th International Conference on Molecular Beam Epitaxy
Nara (Japan), 2012

A. WANG, M.J. TADJER, F. CALLE
"Simulation of thermal management in AlGaN/GaN HEMTs"
International Conference on Diamond and Carbon Materials with diamond heat spreading layers
Granada (Spain), 2012

2013

S. ALBERT, A.BENGOECHEA-ENCABO, Z. GACEVIC, M. SANCHEZ-GARCIA, E. CALLEJA, A. TRAMPERT
"Selective area growth of In(Ga)N/GaN nanocolumns by molecular beam epitaxy on Si(111): from ultraviolet to infrared emission"
ICNS 2013, 10th International Conference on Nitride Semiconductors
Washington – DC Metropolitan Area (USA), 2013

S. ALBERT, A. BENGOECHEA, M. SANCHEZ-GARCIA, E. CALLEJA, A. TRAMPERT, U.JAHN
"Growth and characterization of ordered In(Ga)N/GaN nanocolumnar structures on Si (111) substrates with In contents between 0 and 100%"
E-MRS 2013 Spring Meeting
Strasbourg (France), 2013

S.ALBERT, A. BENGOECHEA, M. SANCHEZ-GARCIA, E. CALLEJA, A. TRAMPERT
"Selective area growth of In(Ga)N/GaN nanocolumns on silicon substrates"
EURO MBE 2013, 17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

A. BENGOECHEA-ENCABO, S. ALBERT, M. SANCHEZ-GARCIA, E.C., A. TRAMPERT, J. ZUÑIGA
"MBE selective area growth of polar, non-polar and semi-polar GaN and InGaN/GaN nanostructures"
E-MRS, Spring Meeting
Strasbourg (France), 2013

A. BENGOECHEA-ENCABO, S. ALBERT, J. ZUÑIGA-PEREZ, A. TRAMPERT, M. SANCHEZ-GARCIA, E. CALLEJA
"Coalescence of selective area growth GaN by MBE, for high quality polar, non polar and semi polar templates"
ICNS 2013, 10th International Conference on Nitride Semiconductors
Washington – DC Metropolitan Area (USA), 2013

A. BENGOECHEA-ENCABO, S. ALBERT, M. SANCHEZ-GARCIA, E. CALLEJA, A. TRAMPERT, J. ZUÑIGA
"Selective area growth of polar, non-polar and semi-polar GaN and InGaN/GaN nanostructures"
EURO MBE 2013, 17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

A. BOSCA, D. LOPEZ-ROMERO, S. ALVAREZ. A. DE ANDRES, J. MARTINEZ, F. CALLE
"Use of PMMA to obtain Graphene layers'
9ª Conf. Dispositivos Electrónicos
Valladolid (Spain), 2013

T. BRAZZINI, A.GUZMAN, F. CALLE
"Nitride 2DEG-based devices for UV photodetection"
10th International Conf. Nitride Semiconductors
Washington DC (USA), 2013

F. CALLE, A. BOSCA, D.J. CHOI, J. PEDROS, J. MARTINEZ
"Graphene: processing and emerging applications"
FECYTMAT, Materials Week
Madrid (Spain), 2013

F. CALLE, J. PEDROS, J. MARTINEZ
"Emerging Applications of Graphene"
Curso de Verano 2013. Universidad Politécnica de Madrid
Madrid (Spain), 2013

F. CALLE, A. BOSCA, D.J. CHOI, J. PEDROS, J. MARTINEZ, L. PEREZ, V. BARRANCO, J.M. ROJO, J.M. AMARILLA
"Graphene-based supercapacitors for electric vehicles"
Jornada I+D+i Vehículos y Transporte UPM
Madrid (Spain), 2013

D. CUCAK, M. VASIC, O. GARCIA, J. OLIVER, P. ALOU, J. A. COBOS, M. TADJER, F. CALLE, F. BENKHELIFA, R. REINER, P. WALTEREIT, S. MULLER,
"Application and Modelling of GaN FET in 1MHz Large Signal Bandwidth Power Supply for Radio Frequency Power Amplifier"
IEEE Applied Power Electronics Conference (APEC Digest),
Long Beach, CA (USA), 2013

D. CUCAK, M. VASIC, O. GARCIA, J. OLIVER, P. ALOU, J. A. COBOS, M. TADJER, F. CALLE, F. BENKHELIFA, R. REINER, P. WALTEREIT, S. MULLER
"Application of GaN FET in 1MHz Large Signal Bandwidth Power Supply for Radio Frequency Power Amplifier"
Actas de "Seminario Anual de Automática, Electrónica Industrial e Instrumentación (SAAEI) "
Madrid (Spain), 2013

A. ELJARRAT, L. LOPEZ-CONESA, Ž. GACEVIC, S. FERNANDEZ-GARRIDO, E. CALLEJA, C. MAGEN, S. ESTRADE, F. PEIRO
"Electron Energy Loss Spectroscopy for the analysis of AlN/GaN interfaces in MBE grown distributed Bragg Reflectors "
EURO MBE 2013, 17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

A. FERNÁNDEZ, R. SANZ, M.DÍAZ-MICHELENA, M. MCHENRY, C. AROCA, M. MAICAS
"Data base of extraterrestrial magnetic minerals, test and magnetic simulation"
12th Joint MMM-Intermag Conference
Chicago (USA), 2013

K. FOTEINOPOULOU, M. LASO
"Simulation of the mechanical response of encapsulated individual cells during normal force spectroscopy measurements"
Trends in Nanotechnology (TNT)
Sevilla (Spain), 2013

Z. GACEVIC, N. VUKMIROVIC, E. CALLEJA
"A Simple Method to Model Bragg Reflectors with Transient Layers Formed at the Interfaces "
ICNS 2013, 10th International Conference on Nitride Semiconductors
Washington – DC Metropolitan Area (USA), 2013

Z. GACEVIC, A. ELJARRAT, LL. LOPEZ-CONESA, S. FERNANDEZ-GARRIDO, C. MAGEN, S. ESTRADE, F. PEIRO, E. CALLEJA
"Insight into AlN/GaN Bragg reflectors with spontaneously formed AlGaN transient layers at the interfaces"
EURO MBE 2013, 17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

Z. GAO, M.F. ROMERO, M.A. PAMPILLON, E. SAN ANDRES, S. MARTIN-HORCAJO, T. BRAZZINI, F. CALLE
"Gd2O3 gate dielectric for AlGaN/GaN HEMTs"
22th European Workshop on Heterostructures Technology
Glasgow (UK), 2013

Z. GAO, M.F. ROMERO, F. CALLE
"Etching of AlGaN/GaN by Cl2 –based ICP"
9th Conf. Dispositivos Electrónicos, CDE´2013
Valladolid (Spain), 2013

N. GARCIA-LEPETIT, Z. GACEVIC, S. ALBERT, A. BENGOECHEA-ENCABO, M. SANCHEZ-GARCIA, E. CALLEJA
"Localized emission from the apex of GaN/(In,Ga)N/GaN pyramidal-top nanocolumns grown in ordered arrays"
ICNS 2013, 10th International Conference on Nitride Semiconductors
Washington – DC Metropolitan Area (USA), 2013

C. HAHN, G. DE LOUBENS, V.V. NALETOV, O. KLEIN, O. D'ALLIVY KELLY, A. ANANE, R. BERNARD, V. CROS, J.L. PRIETO, M. MUÑOZ
"Ferromagnetic Resonance and Spin Pumping in YIG and YIG|Pt Nanodiscs Investigated by MRFM"
58th Annual Conference on Magnetism and Magnetic Materials
Denver, Colorado (USA), 2013

M. HOLGADO, F.J. SANZA, M.F. LAGUNA, R. CASQUEL, A. LAVIN, A. LOPEZ, M.J. BAÑULS, C.A. BARRIOS, V. CANALEJAS, R. PUCHADES
"Biophotonic sensing cells for measuring biological agents"
Biosensors and Bioelectronics
Chicago (USA), 2013

M. HOLGADO, F.J. SANZA, A. LAVIN, R. CASQUEL, M.F. LAGUNA, J. DE VICENTE, A. LOPEZ, M.J. BAÑULS, C.A. BARRIOS, V. CANALEJAS, R. PUCHADES
"Biophotonic sensing cells optimization for label-free biosensing"
VIII Reunión Española de Optoelectrónica (OPTOEL´13)
Alcalá de Henares (Spain), 2013

A. KURTZ, A. HIERRO, G.TABARES, E. MUÑOZ, S. KUMAR MOHANTA, ATSUSHI NAKAMURA, J. TEMMYO
"Acceptor Levels Probed by DLOS in ZnMgO:N"
16th International Conference on II-VI Compounds and Related Materials (II-VI 2013)
Nagahama (Japan), 2013

E. LUNA, J. PUUSTINEN, M. J. MILLA, M. GUINA
"Lateral composition modulations in GaAs1-xBix layers grown by molecular-beam-epitaxy"
EURO MBE 2013, 17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

F. LLORET, D. ARAUJO, M.P. VILLAR, J.G. RODRIGUEZ-MADRID, G.F. IRIARTE, O. A. WILLIAMS, F. CALLE
"Diamond substrate microstructure effect on the orientation of AlN piezoelectric layers for high frequency SAW resonators by TEM"
18th Diamond Workshop
Hasselt (Belgium), 2013

M. MAICAS
"Micromagnetic simulation"
1st Workshop on Magnetism in Space
Puerto de Navacerrada (Madrid-Spain), 2013

J.M. MANUEL, F.M. MORALES, J.J. JIMENEZ, R. GARCIA, P.E.D. SOTO RODRIGUEZ, P. KUMAR, V.J. GOMEZ, N.H. ALVI, E. CALLEJA, R. NÖTZEL
"TEM study of spontaneous formation of InGaN nanowall network directly on Si for PV"
European Congress on Advanced Materials and Processes (EuroMat2013)
Sevilla (Spain), 2013

J. MARTINEZ, D.J. CHOI, S. SHRESTHA, T. VALERO, A. BOSCA, J. PEDROS, F. CALLE
"Flexible graphene device for lighting LEDs"
Graphene 2013
Bilbao (Spain), 2013

J. MARTINEZ, A. BOSCA, J. PEDROS, D. J. CHOI, S. SHRESTHA, V. BARRANCO, J.M. ROJO, F. CALLE
"3D graphene supercapacitor for energy applications"
Trends in NanoApplications Energy, TNA 2013
Bilbao (Spain), 2013

S. MARTIN-HORCAJO, M.F. ROMERO, Z. GAO, A. WANG, M.J. TADJER, A.D. KOEHLER, T.J. ANDERSON, F. CALLE
"Thermal stability of GaN on-Si HEMTs with different cap layers: GaN, in situ SiN, and in situ SiN/GaN"
10th International Conference on Nitride Semiconductors
Washington, DC (USA), 2013

MJ. MILLA RODRIGO, J.M ULLOA, Á.GUZMAN FERNANDEZ
"High performance environment sensors based on InGaAs surface Quantum Dots"
17th European Molecular Beam Epitaxy Workshop
Levi (Finland), 2013

C. MUNUERA, M. GARCIA-HERNANDEZ, A. BENGOECHEA-ENCABO, S. ALBERT, M. A. SANCHEZ-GARCIA, E. CALLEJA, F. CALLE, J. MARTINEZ
"AFM electrical characterization of graphene nano LEDs"
Scanning Probe Microscopies 2013
Bilbao (Spain), 2013

G.M. MUTTA, T. BRAZZINI, D.N. FAYEA, L. MECHIN, J.-M. ROUTOURE, B. GUILLET, F. CALLE, P. RUTERANA
"PAMBE grown InN layers electrical conduction by low frequency noise technique"
27th International Conference on Defects in Semiconductors.
Bologna (Italy), 2013

J. PEDROS, J. MARTINEZ, A. BOSCA, A. DEL CAMPO, C. NOVILLO, A. SAEZ-MADERUELO, G. DE DIEGO, F. CALLE
"Correlation between graphene properties and substrate grain structure in CVD fabrication"
Workshop on High Structural and Spatial Resolution using Raman Confocal and Scanning Probe Microscopy, ICV-CSIC
Cantoblanco, Madrid (Spain), 2013

J. PEDROS, K.B.K. TEO, J. MARTINEZ, S. ÁLVAREZ-GARCIA, A. BOSCA, A. de ANDRES, F. CALLE
"Chemical vapour deposition of graphene on 3-dimensional metal foams for energy-storage applications"
Graphene 2013
Bilbao (Spain), 2013

R. RANCHAL, C.AROCA-HERNÁNDEZ ROS
"Tailoring the magnetic domain patterns of sputtered TbFeGa Alloys"
Joint European Magnetic Symposia
Rhodes (Greece), 2013

D. F. REYES, J. M. ULLOA, A. HIERRO, D.L. SALES, L.D. BLANCO, R. BEANLAND, A.M. SANCHEZ, J.M. LLORENS, B. ALEN, D. GONZALEZ
"Impact of annealing on the Sb and In distribution in GaAsSb-capped InAs quantum dots"
EUROMAT 2013
Sevilla (Spain), 2013

M.F. ROMERO, S. MARTIN-HORCAJO, Z. GAO, A. WANG, M.J. TADJER, A.D. KOEHLER, T.J. ANDERSON, F. CALLE
"Thermal stability of GaN on-Si HEMTs with different in situ cap layers"
37th International Workshop on Compound Semiconductors and Integrated Circuits, Wocsdice 2013.
Warnemünde (Germany), 2013

M.F. ROMERO, M. FENEBERG, A. MINJ, A. CAVALLINI, P. GAMARRA, M.-A. DI FORTE POISSON, A. VILALTA-CLEMENTE, P. RUTERANA, F. CALLE, R. GOLDHAHN
"Two dimensional electron gas related luminescence in InAl(Ga)N/AlN/GaN-based heterostructures"
9ª Conf. Dispositivos Electrónicos, CDE'2013
Valladolid (Spain), 2013

M.A. SANCHEZ-GARCIA, S.ALBERT, A. BENGOECHEA-ENCABO, F. BARBAGINI, J. MARTINEZ, E. CALLEJA, U. JAHN, A. TRAMPERT
"Selective area growth of InGaN/GaN nanostructures for green and white light emission"
7th Nanowire Growth Workshop
Lausanne (Switzerland), 2013

M.J. TADJER, M.A. MASTRO, J.M. ROJO, A. BOSCÁ, F. CALLE, F. KUB, C.R. EDDY, JR.
"MnO2-based electrochemical supercapacitors on flexible carbon substrates"
Trends in NanoApplications Energy, TNA 2013
Bilbao (Spain), 2013

J. M. ULLOA, J.M. LLORENS, B. ALEN, D. F. REYES, D.L. SALES, D. GONZALEZ, A. GUZMAN, A. HIERRO
"High efficient luminescence in type-II GaAsSb-capped InAs quantum dots upon annealing"
17th European Molecular Beam Epitaxy workshop
Levi (Finland), 2013

J.L. URRACA, C. ANGULO BARRIOS, B. SELLERGREN, D M.C. MORENO-BONDI
"New trends and applications of imprinted polymers in molecular recognition"
VI Workshop on Analytical Nanoscience and Nanotechnology (VI NyNA 2013)
Alcalá de Henares (Spain), 2013

A.D. UTRILLA, J.M. ULLOA, A. GUZMAN, A. HIERRO
"Impact of a thin GaAsSb capping layer on the lasing characteristics of InAs/GaAs quantum dot lasers"
17th European Molecular Beam Epitaxy workshop
Levi (Finland), 2013

A.D. UTRILLA, J. M. ULLOA, L. DOMINGUEZ, D. F. REYES, D. GONZALEZ, A. GUZMAN, A. HIERRO
"Room temperature luminescence beyond 1.3 µm from GaAsSbN-capped InAs quantum dots"
Novel Gain Materials and Devices Based on III-V-N/Bi Compounds
Istambul (Turkey), 2013

A. WANG, M.J. TADJER, T.J. ANDERSON, R. BARANYAI, J.W. POMEROY, T.I. FEYGELSON, K.D. HOBART, B.B. PATE, F. CALLE, M. KUBALL
"Impact of Intrinsic Stress in Diamond Capping Layers on the Electrical Behavior of AlGaN/GaN HEMTs"
10th International Conference on Nitride Semiconductors.
Washington DC, (USA), 2013

2014

M. ABUIN, M. MAICAS, L. PEREZ, A. MASCARAQUE
"Control of magnetic properties of FeCo thin films grown by sputtering"
CEMAG 2014
Benasque (ESPAÑA), 2014

S. ALBERT, A. BENGOECHEA-ENCABO, M. SABIDO-SILLER, M. MÜLLER, G. SCHMIDT, S. METZNER, P. VEIT, F. BERTRAM, M. A. SANCHEZ-GARCIA, J. CHRISTEN AND E. CALLEJA
"Growth and characterization of InGaN/GaN core-shell structures by molecular beam epitaxy"
IWN 2014 International Workshop on Nitride Semiconductors
Wroclaw (Polonia), 2014

S. ALBERT, A. BENGOECHEA-ENCABO, M. SABIDO-SILLER, M. MÜLLER, G. SCHMIDT, S. METZNER, P. VEIT, F. BERTRAM, M. A. SÁNCHEZ-GARCÍA, J. CHRISTEN, E. CALLEJA
"Growth of InGaN/GaN core-shell structures by molecular beam epitaxy"
E-MRS 2014 Spring Meeting
Lille (Francia), 2014

C. ANGULO
"**Biosensado con redes de nanoagujeros en oxido de aluminio**"
VIII International Workshop on Sensors and Molecular Recognition
Burjassot (Spain), 2014

C. ANGULO
"Tuning the selectivity of molecularly imprinted polymers for the analysis of antimicrobial residues by SPE-HPLC"
14th Instrumental Analysis Conference
Barcelona (Spain), 2014

A. BENGOECHEA-ENCABO,S. ALBERT, D. LOPEZ-ROMERO, F. BARBAGINI, ALMUDENA TORRES-PARDO, J. M. GONZALEZ-CALBET, M. A. SANCHEZ-GARCIA, E. CALLEJA
"Blue, green and yellow light – emitting diodes based on ordered InGaN nanocolumns by PAMBE"
E-MRS 2014 Spring Meeting
Lille (Francia), 2014

A. BENGOECHEA-ENCABO, S. ALBERT, D. LOPEZ-ROMERO, A.TORRES-PARDO, J. M. GONZALEZ-CALBET, P. LEFEBVRE, M. A. SANCHEZ-GARCIA, E. CALLEJA
"Blue, green and yellow light – emitting diodes based on ordered InGaN nanocolumns by PAMBE"
IWN 2014 International Workshop on Nitride Semiconductors
Wroclaw (Polonia), 2014

A. BOSCA, J. PEDROS, J. MARTINEZ, T.CASPER,F.CALLE
"Electrical model for characterizing CVD graphene"
Nanospain 2014
Madrid, 2014

A. BOSCA, J. PEDROS, J. MARTINEZ, F.CALLE
"Graphene foam functionalized with electrodeposited nickel hydroxide for energy applications"
Diamond and Carbon Structures 2014
Madrid, 2014

A. BOSCA, J. PEDROS, J. MARTINEZ, F.CALLE
"Polyaniline-coated carbon papers for supercapacitor electrodes"
Int. Conf. on Electronic Materials and Nanotechnology for Green Environment, ENGE 2014
Jeju (South Korea), 2014

A. BOSCA, T.CASPER, J. PEDROS, J. MARTINEZ, F.CALLE
"Method for electrical evaluation of graphene using a GFET structure"
Graphene 2014
Toulouse (Francia), 2014

V. CANALEJAS, C. ANGULO
"MIP-based optical sensing strategies: pros and cons"
8th International Conference on Molecular Imprinting (MIP2014)
Zhenjiang (China), 2014

V. CANALEJAS, C. ANGULO
"Light, MIPs and Nanotechnology: A Sound Medley to Tackle Analytical Challenges"
The 8th International Conference on Molecular Imprinting (MIP2014)
Zhenjiang (China), 2014

A. FOTEINOPOULOU, N. KARAGIANNIS, M. LASO
"Numerical study of ultrasound induced non-linear shape and size bubble oscillations in viscoelastic media"
1st International Conference on Ultrasonic-based Applications: From Analysis to Synthesis
Caparica (Portugal), 2014

A. FOTEINOPOULOU, N. KARAGIANNIS, M. LASO
"Packing of atermal polymers in the bulk and under confinement"
Packing and Jamming of Particulate Systems (Jam Packed)
Erlagnen (Germany), 2014

G.FUENTES, F. CALLE
"TEM study of the AlN grain orientation grown on NCD diamond substrate"
EXMATEC 2014
Dephi (Greece), 2014

A.HIERRO
"Deep and shallow traps in ZnMgO:N"
SPIE Photonics West
San Francisco (USA), 2014

A.HIERRO, G.TABARES, E. MUÑOZ
"Light Polarization Sensitive Photodetectors with Non-Polar and Semi-Polar Homoepitaxial ZnO/ZnMgO MQWs"
8th International Workshop on Zinc Oxide and Related Materials
Niagara (Canada), 2014

A. HIERRO
"Lattice Structural Effects on Native Point Defect Densities and Energies across MgZnO Alloys"
8th International Workshop on Zinc Oxide and Related Materials
Niagara (Canada), 2014

N. KARAGIANNIS
"Jamming, glass formation and crystallization in systems of anisotropic particles"
American Physical Society (APS) March meeting 2014
Denver (USA), 2014

A.KURTZ, A. HIERRO, E.MUÑOZ
"Deep Level Analysis of Homoepitaxial ZnO Doped with N"
Materials Research Society fall meeting 2014
Boston (USA), 2014

M. LOPEZ , J.M. ULLOA, E. MUÑOZ, , A. HIERRO
"ZnCdO/ZnO Multiple Quantum Well Nanowires Emitting in the Visible"
8th International Workshop on Zinc Oxide and Related Materials
Niagara (Canada), 2014

M. LOPEZ, J.M. ULLOA, E.MUÑOZ, A.HIERRO
"Morphological and Structural Characterization of $Mg_xZn_{1-x}O$"
8th International Workshop on Zinc Oxide and Related Materials
Niagara (Canada), 2014
M. LOPEZ, G. TABARES, E. MUÑOZ, J.M. ULLOA, A. HIERRO
"Optical Properties of ZnMgO Grown by Spray Pyrolysis and Development of MSM Photodetectors for the UV"
8th International Workshop on Zinc Oxide and Related Materials
Niagara (Canada), 2014

J.MARTINEZ, A. BOSCA, J. PEDROS, F.CALLE
"Flexible Graphene device for ligthing LEDs"
Nanospain 2014
Madrid, 2014

J.L. MESA, A.B.FERNANDEZ, C.HERNANDO, M.E.MCHENRY, C. AROCA, M.T.ALVAREZ, M. DIAZ-MICHELENA
"Effects of gamma-Ray Radiation on Magnetic Properties of NdFeB and SmCo Permanent Magnets for Space Applications"
2014 IEEE Radiation Effects Data Workshop (REDW)
Paris (France), 2014

J.PEDROS, F. CALLE
"Coupling light into graphene plasmons with the help of surface acoustic waves"
Nanospain 2014
Madrid

J.L. PRIETO, M. MAICAS, M. MUÑOZ, J. AKERMAN
"Selective injection of magnetic domain walls in Permalloy nanostripes"
IEEE International Magnetic Conference
Dresden (Alemania.), 2014

R. RANCHAL, C.AROCA-HERNÁNDEZ ROS
"Tailoring the magnetic domain patterns of sputtered TbFeGa Alloys"
Joint European Magnetic Symposia
Rhodes (Greece), 2013

F. ROMERO, F.CALLE
"Field-dependent photoluminescence of InAlN/GaN based HEMT structures"
DPG Spring Meeting
Desden (Germany), 2014

J.M. ULLOA
"Height control of self-assembled quantum dots"
8th Internacional Conference on Quantum Dots
Pisa (Italy), 2014

J.M. ULLOA
"2.18 μm Mid IR emission from highly transparent Er 3+ doped tellurite glass ceramic for bio applications"
Fundamental Science
San José (USA), 2014

A. UTRILLA, J.M. ULLOA, Z. GACEVIC, A. GUZMAN FERNANDEZ, A. HIERRO
"Stacked GaAsSbN-capped InAs/GaAs quantum dots for enhanced solar cell efficiency"
18th Internationa conference on Molecular Beam Epitaxy
Flagstaff (USA), 2014

V.G. ZHAN, F. ROMERO, F. CALLE
"Temperature performance of AlGaN/GaN MOS-HEMTs on Si substrates using Gd_2O_3 as gate dielectric"
23th European Workshop on Heterostructures Technology
Giessen (Germany), 2014

8.3 Invited Talks

2010

C. AROCA, J.L.PRIETO
"Espintrónica"
Workshop Materiales de interés Tecnológico
Hotel Aruá in Presidente Prudente, SP
Presidente Prudente (Brazil), 2010

F. CALLE et al.
"KORRIGAN: III-Nitrides 2DEG Structutres and HEMTs- Technology and Characterization"
Jornada Tecnológica: Materiales de Gap ancho y Electrónica de potencia. CDTI
Madrid (Spain), 2010

F. CALLE, M. TADJER
"Overview III-N HEMTs: materials and technology"
Consolider RUE Workshop on WBS for Power Applications, CNM
Barcelona (Spain), 2010

E. CALLEJA et al.
"InGaN-based films and nanocolumnar heterostructures for photovoltaic applications"
MCINN-JST Joint Workshop on "Nanoscience and New Materials for Environmental Challenges"
Barcelona (Spain), 2010

E. CALLEJA et al.
"On the spontaneous and ordered growth of III-N nanocolumns: growth on nonpolar substrates and applications to Optoelectronic Devices"
XXXIX "Jaszowiec" International School & Conference on the Physics of Semiconductors
Krynica-Zdroj (Poland), 2010

E. CALLEJA et al.
"MBE growth of nitrides"
RAINBOW SECOND TRAINING WORKSHOP on "Growth and properties of InN and indium containing alloys"
Madrid (Spain), 2010

E. CALLEJA, A. BENGOECHEA-ENCABO, J. GRANDAL, S. FERNÁNDEZ, J. RISTIC, M.A. SANCHEZ-GARCÍA, F. BARBAGINI, P. LEFEBVRE, J.M. CALLEJA, E. GALLARDO, E.LUNA, A. TRAMPERT, U.JAHN.
"Spontaneous and ordered growth of III-N nanocolumns by MBE: growth mechanisms and applications to Optoelectronic Devices"
International Workshop on Nitride Semiconductors (IWNS 2010)
Tampa, Florida (USA), 2010

E. CALLEJA et al.
"Spontaneous and ordered growth of III-N nanorods: application to Light emitters and Photovoltaics"
2010 Workshop on Innovative Devices and Systems (WINDS)
Hawaii (USA), 2010

A.HIERRO et al.
"ZnMgO-based UV Photodetectors"
Instituto de Ciencias de Materiales de Madrid, CSIC
Madrid (Spain), 2010

D. HILL, N. SANDSTRÖM, K. GYLFASON, F. CARLBORG, M. KARLSSON, T. HARALDSSON, H. SOHLSTRÖM, A. RUSSOM, G. STEMME, T. CLAES, P. BIENSTMAN, A. KAZMIERCZAK, F. DORTU, M.J. BAÑULS POLO, A. MAQUIEIRA CATALA, G. KRESBACH, L. VIVIEN, J. POPPLEWELL, G. RONAN, C.A. BARRIOS, W. VAN DER WIJNGAART
"Microfluidic and Transducer Technologies for Lab on a Chip Applications"
32nd Annual International IEEE EMBS Conference
Buenos Aires (Argentina), 2010

N. C. KARAYIANNIS et al.
"Structure, topology and phase transitions in dense packings of model polymers"
4th Meeting on High Performance Computing in Molecular Simulation
Madrid (Spain), 2010

N. C. KARAYIANNIS et al.
"Multi-scale modeling of polymers: structure-property relation"
Harbin Institute of Technology
Harbin (China), 2010

P. LEFEBVRE et al.
"Internal efficiency of LEDs: An application of Quantum Mechanics"
ForumLED
Lyon (France), 2010

M. TADJER, F. CALLE
"Overview III-N HEMTs: device design"
Consolider RUE Workshop on WBS for Power Applications. CNM, Barcelona,
Barcelona (Spain), 2010

2011

F. CALLE, S. MARTÍN-HORCAJO, R. CUERDO, M.J. TADJER, M.F. ROMERO, J. GRAJAL, E. MUÑOZ
"Thermal assessment of Al(GaIn)N/GaN HEMTs"
Frontier Photonic and Electronic Materials and Devices, Ge-Jp-Sp Workshop,
Granada (Spain), 2011

F. CALLE, J. PEDRÓS, J. RODRÍGUEZ, G. FUENTES, T. PALACIOS, J. GRAJAL
"Surface acoustic waves III-nitrides: from materials to applications"
Seminarios Internacionales de Fronteras de la Ciencia de Materiales, ETSCCyP-UPM
Madrid (Spain), 2011

F. CALLE, S. MARTÍN-HORCAJO, R. CUERDO, A. BOSCÁ, M.F. ROMERO, M.J. TADJER, J. GRAJAL, E. MUÑOZ
"High temperature assessment of Al(GaIn)N/GaN HEMTs for RF and power applications"
Topical Workshop on Heterostructure Microelectronics
Gifu (Japan), 2011

F. CALLE, D. LÓPEZ-ROMERO, A. BOSCÁ, T. PALACIOS
"Technology for graphene-based nanoelectronic devices"
Sectorial Meeting Graphene for ICT
Castelldefels (Spain), 2011

E. CALLEJA, A. BENGOECHEA-ENCABO, S. ALBERT, M.A. SÁNCHEZ-GARCÍA, F. BARBAGINI, E. LUNA, A. TRAMPERT, U. JAHN , P. LEFEBVRE
"Efficient phosphor-free, white light emission by using ordered arrays of GaN/InGaN nanocolumnar LEDs grown by Selective Area MBE"
Best Paper Award was selected for the oral presentation in Workshop On Frontiers in Electronics (WOFE 2011)
San Juan (Puerto Rico), 2011

E. CALLEJA et al.
"Understanding of the nucleation and growth of ordered GaN nanocolumns by MBE on GaN templates"
11th International Conference on Physics of Light-Matter Coupling in Nanostructures (PLMCN 2011)
Berlin (Germany), 2011

E. CALLEJA et al.
"Effect of local III/V ratio on the nucleation and growth of ordered GaN nanocolumns by MBE on GaN templates"
German-Japanese-Spanish Meeting
Granada (Spain), 2011

E. CALLEJA et al.
"Self-assembled versus selective area growth of (In)GaN nanocolumns by MBE: from physics to applications in phosphor-free white lighting and photovoltaics"
Chinese-German bilateral Workshop on Semiconductor Nanodevices and their Application in Optoelectronics and Biochemical Sensors
Suzhou (China), 2011

A. GUZMÁN, R. GARGALLO-CABALLERO, R. SAN ROMÁN
"New approaches for room temperatura operation of quantum infrared photodetectors"
2011 German-Japanese-Spanish Joint Workshop on Frontier Photonic and Electronic Materials and Devices
Granada (Spain), 2011

A. HIERRO, G. TABARES, C. DEPARIS, C. MORHAIN, J.-M. CHAUVEAU
"ZnO/ZnMgO QW Schottky photodiodes sensitive to light polarization"
SPIE Photonics West
San Francisco (USA), 2011

A.HIERRO et al
"Oxide-based UV Photodetection"
The Institute for Materials Research and the Solid State Electronics and Photonics (SSEP) Seminar Series.The Ohio State University
Columbus-Ohio (USA), 2011

A. HIERRO, G. TABARES, JM.ULLOA, A. GUZMAN, E.MUÑOZ, C, DEPARIS, C MORHAIN, JM. CHAUVEAU, A. NAKAMURA, T. HAYASHI, J.TEMMYO.
"Oxide based UV photodetection using schottky photodiodes"
2011 German-Japanese-Spanish Joint Workshop on Frontier Photonic and Electronic Materials and Devices
Granada (Spain), 2011

G.F. IRIARTE, J.G. RODRÍGUEZ, O.A. WILLIAMS, D. ARAÚJO, M.P. VILLAR, F. CALLE
"High frequency SAW devices on AlN/diamond"
EPS Global 1st International High Technology Conference
Shenzhen (China), 2011

GF. IRIARTE, J.G. RODRÍGUEZ-MADRID, R. RO, R. LEE, F. CALLE
"AlN/diamond heterostructures for SAW resonators above 10 GHz"
TACT 2011 International Thin Films Conference
Kenting (Taiwan), 2011

N. C. KARAYIANNIS et al.
"Polymer dynamics: Entanglements and Architectures"
DYNACOP-CECAM Workshop,
Anacapri (Italy), 2011

P. LEFEBVRE, S. ALBERT, J. RISTIĆ, S. FERNÁNDEZ-GARRIDO, J. GRANDAL, M.-A. SANCHEZ-GARCÍA, E. CALLEJA.
"Surface-related optical properties of GaN and InGaN nanocolumns"
E-MRS Srping Meeting
Nice (France), 2011

M.C. MORENO-BONDI, G. ORELLANA, F. NAVARRO, A.B. DESCALZO, E. BENITO-PEÑA, J.URRACA, J. ZDUNEK, S. CARRASCO, C. A. BARRIOS
"Potencial Analítico de los Polímeros de Impronta Molecular (MIPs) como Elementos de Reconocimiento Biomimético"
XXXIII Reunión Bienal de la Real Sociedad Española de Qumica
Valencia (Spain), 2011

M.C. MORENO-BONDI, G. ORELLANA, F. NAVARRO, A.B. DESCALZO, E. BENITO-PEÑA, J. URRACA, J. ZDUNEK, S. CARRASCO, C. A. BARRIOS, K. HAUPT
"Aplicaciones analíticas y nuevos formatos de los polímeros de impronta molecular"
V Workshop Nanociencia y Nanotecnología Analíticas 2011
Toledo (Spain), 2011

M.C. MORENO-BONDI, G. ORELLANA, F. NAVARRO, A.B. DESCALZO, E. BENITO-PEÑA, J. URRACA, J. ZDUNEK, S. CARRASCO, C. A. BARRIOS
"Potencial Analítico de los Polímeros de Impronta Molecular (MIPs) como Elementos de Reconocimiento Biomimético"
XXXIII Reunión Bienal de la Real Sociedad Española de Qumica. Proceedings de la conferencia
Valencia (Spain), 2011

E. MUÑOZ, A. NAVARRO, J. PEREIRO, A.REDONDO-CUBERO
"(In,Ga,Al)N photodetectors and applications in biophotonics"
Workshop on Frontier Photonic and Electronic Materials and Devices, Ge-Jp-Sp Workshop.
Granada (Spain), 2011

M A. SANCHEZ-GARCIA, S.ALBERT, A. BENGOECHEA-ENCABO, P. LEFEBVRE, E. CALLEJA, E. LUNA, A.TRAMPERT
"MBE growth and characterization of InGaN-based films and nanocolumns on Silicon substrates and GaN templates"
Workshop on Frontier Photonic and Electronic Materials and Devices, Ge-Jp-Sp Workshop.
Granada (Spain), 2011

M.A. SANCHEZ-GARCIA, A.BENGOECHEA-ENCABO, S.ALBERT, F. BARBAGINI, E. CALLEJA, U. JAHN, E. LUNA, A.TRAMPERT
"Understanding the selective area nucleation and growth of GaN nanocolumns by MBE using Ti nanomasks"
GdR Nanofils Semiconducteurs, Workshop in Porquerolles (Francia), 17-21 October 2011

2012

C. A. BARRIOS
"Submicron Structures for Label-Free Optical Biosensing"
School of Physics and Astronomy
University of St Andrews (UK), 2012

F. CALLE, J.G. RODRÍGUEZ, G.F.IRIARTE, J. PEDRÓS, O. WILLIAMS, M. VILLAR, D. ARAÚJO, R.RO. R. LEE
"High frequency AlN/diamond SAW devices"
11th Expert Evaluation and Control of Compound Semiconductor Materials and Technologies, EXMATEC
Porquerolles (France), 2012

F. CALLE, T.A. PALACIOS
"Nanotechnology for high frequency communications: nitrides and graphene"
Trends in Nanotechnology, TNT 2012
Madrid (Spain), 2012
F. CALLE, A. BOSCÁ, J. PEDRÓS, M. TADJER, J. MARTÍNEZ
"Short term applications of graphene"
ULab – Nanotech
Venezia (Italy), 2012

E. CALLEJA et al.
"GaN growth by plasma-MBE"
Workshop on GaN Growth, within SMASH Project
Valbonne (France), 2012

E. CALLEJA et al.
"Efficient green emission and phosphor-free white lighting based on nanoLED ordered arrays grown by Selective Area MBE"
Advanced Research Workshop on "*Future Trends in Microelectronics: Into the Cross Currents*", 7th FTM
Corsica (France), 2012

E. CALLEJA et al.
"Selective Area Growth of polar, semi-polar, and non-polar III-Nitride nanostructures by MBE"
Chinese-German bilateral Workshop on “Frontier research on smart nano-devices”
Braunschweig (Germany), 2012

E. CALLEJA et al.
"Selective Area Growth of polar, semi-polar, and non-polar III-Nitride nanostructures by MBE"
2012 German-Japanese-Spanish Joint Workshop on Frontier Photonic and Electronic Materials and Devices
Berlin (Germany), 2012

E. MUÑOZ et al.
"Zn(Mg,Cd)O epilayers and nanostructures for optoelectronics"
2012 German-Japanese-Spanish Joint Workshop on Frontier Photonic and Electronic Materials and Devices
Berlin (Germany), 2012

G. ORELLANA, E. MUÑOZ, L.K. GIL-HERRERA, P. MUÑOZ, J. LOPEZ-GEJO, C.PALACIO
"Integrated luminescent chemical microsensors based on GaN LEDs for security applications using smartphones"
SPIE Security+Defence, Vol. 8545 (2012)
Edinburgh, Scotland (UK), 2012

G. ORELLANA, LUZ K. GIL HERRERA, J. LÓPEZ-GEJO, ELIAS MUÑOZ, P. MUÑOZ
"Photochemistry of hybrid gan semiconductor/luminescent dye composites for chemical microsensors and dye-sensitized solar cells"
XXIV Iupac Symposium on Photochemistry
Coimbra (Portugal), 2012

J. PEDRÓS, F. CALLE, J. GRAJAL, C.J.B. FORD
"Acoustoelectronics in AlGaN/GaN: from frequency control to single-electron transport applications"
36th Workshop Compound Semiconductors and Integrated Circuits, WOCSDICE
Porquerolles (France), 2012

J. PRIETO et al.
"Inverse spin transfer torque at the Fe/Gd interface of a magnetic nano-pillar"
Nanogune 2012
Barcelona (Spain), 2012

A. REDONDO-CUBERO, K. LORENZ, E. ALVES, R. GAGO, A. HIERRO, M. VINNICHENKO, J.-M. CHAUVEAU, A. NAKAMURA, M. KRAUSE, J. TEMMYO, E. MUÑOZ, M. BRANDT, F. HENNEBERGER
"Ion beams as a tool for advanced structural characterization in ZnO-based materials"
Society of Photo-Optical Instrumentation Engineers (SPIE Photonics West - OPTO),
San Francisco (USA), 2012

M.A. SANCHEZ-GARCIA et al.
"Influence of substrate type and orientation on the morphology and optical properties of selective area growth of GaN and InGaN nanocolumns"
2012 German-Japanese-Spanish Joint Workshop on Frontier Photonics and Electronic Materials and Devices
Berlin (Germany), 2012

J. M. ULLOA et al.
"Cross-sectional scanning tunneling microscopy of semiconductor nanostructures"
Training School on the Epitaxy and structural análisis of III-N-V semiconductor nanostructures – Site controlled epitaxy workshop
Heraclion-Crete (Greece), 2012

M. J. TADJER, T.J. ANDERSON, K.D. HOBART, T.I. FEYGELSON, M.G. ANCONA, A.D. KOEHLER, J D. CALDWELL, A. WANG, F. CALLE, B. PATE, F.J. KUB, C.R. EDDY
"Heat spreading in III-nitride HEMTs by diamond integration"
21th European Workshop on Heterostructures Technology
Barcelona (Spain), 2012

NIKOS CH. KARAYIANNIS
"Understanding entangled polymers: what we can learn from athermal chain packings"
PS Meeting 2012
Boston (USA), 2012

2013

N.H. ALVI, R. NÖTZEL
"InN/InGaN quantum dots: A surprise for highly sensitive and fast potentiometric biosensors"
Conference on Solid State Devices and Materials (SSDM2013)
Fukuoka (Japan), 2013

F. CALLE, A. BOSCA, J. PEDROS, J. MARTINEZ
"Energy Storage based in Graphene"
Graphene Closing Meeting
Tres Cantos, Madrid (Spain), 2013

F. CALLE, A. BOSCA, D. LOPEZ-ROMERO, J. PEDROS, J. MARTINEZ
"Tecnología para nanoelectrónica de grafeno"
Proyectos Flagship “Grafeno y El Cerebro Humano”
Universidad Internacional Menéndez Pelayo. Santander (Spain), 2013

E. CALLEJA et al.
"Advances on MBE Selective Area Growth of III-Nitride nanostructure: from nanoLEDs to pseudo substrates"
Workshop on frontier Electronic, WOFE 2013
San Juan, Puerto Rico (USA), 2013

E. CALLEJA et al.
"Selective Area Growth of InGaN/GaN nanorods on polar, semipolar and non-polar substrates: emission from UV to IR and white light"
International Nano-Optoelectronics Workshop (iNOW2013)
Cargese, Corsica (FRANCE), 2013

E. CALLEJA et al.
"Selective area growth of InGaN/GaN nanostructures for green and white light emission"
SPIE Photonics West Conference
San Francisco (USA), 2013

E. CALLEJA et al.
"Functional materials in the nanotechnology era, what are they? What for?"
Workshop on Nanotechnology and Nanomaterials. MaterialsWeek (La Semana de los Materiales). CEI Campus Moncloa.
Madrid (Spain), 2013

J. MARTINEZ et al.
“Graphene: 2D &3D devices”
Seminarios Internacionales Fronteras de la Ciencia de Materiales. ETS Ingenieros Caminos, Canales y Puertos. UPM
Madrid (Spain), 2013

E. MUÑOZ et al.
"UV-VIS Optoelectronics with Oxides"
Nanotechnologies and New Materials for Environmental Challenges, Sp-Jp Bilateral Workshop
Nano2013 (JST)
Tsukuba (Japan), 2013

E. MUÑOZ et al.
"AlGaInN/GaN HEMT. Some Device and Materials Issue"
10th International Conference on Electrical Engineering, Computing Science and Automatic Control (CCE 2013)
Mexico City (Mexico), 2013

J. PEDROS, A. BOSCA, D.J. CHOI, S. SHRESTA, J. MARTINEZ, F. CALLE
"Energy storage systems based on graphene"
Curso de Verano UPM sobre “Emerging Applications of Graphene”
Madrid (Spain), 2013

J. PEDROS, J MARTINEZ, A. BOSCA, A. DEL CAMPO, C. NOVILLO, A. SAEZ-MADERUELO, G. DE DIEGO, F. CALLE
"Correlation between graphene properties and substrate grain structure in CVD fabrication"
Workshop on High Structural and Spatial Resolution using Raman Confocal and Scanning Probe Microscopy
Madrid (Spain), 2013

M.F. ROMERO ROJO et al
"Thermal assessment of GaN on-Si HEMTs and diodes with different cap layers: GaN, in situ SiN, and in situ SiN/GaN"
Seminar Neue Materialen – Halbleite OTTO-VON-GUERICKE-UNIVERSITÄT MAGDEBURG
Fakultät für Naturwissenschaften. Institut für Experimentelle Physik / Institut für Theoretische Physik
Magdeburg (Germany), 2013

M.A. SANCHEZ-GARCIA, A. BENGOECHEA-ENCABO, S. ALBERT, E. CALLEJA, A. TRAMPERT
"Selective Area Growth of III-N Nanostructrures for Optoelectronic Applications"
17th European Molecular Beam Epitaxy Workshop. EURO MBE 2013.
Levi (Finland), 2013

J. SCHIEFELE, J. PEDROS, F. SOLS, F. CALLE, F. GUINEA
"Coupling light into graphene plasmons through surface acoustic waves"
Final network meeting and workshop - Nanoelectronics: Concepts, Theory and Modelling
Pozna (Poland), 2013

R. NÖTZEL et al
"Near-infrared InN quantum dots on high-In-composition InGaN for solar cells and biosensors"
International Conference on Nanoscience and Technology (ChinaNano2013)
Beijing (China), 2013

J. M. ULLOA, A. D. UTRILLA, A. GUZMAN, A. HIERRO, D. F. REYES, D. GONZALEZ, J. KEIZER, P. M. KOENRAAD
"GaAsSb(N)-capped InAs quantum dots: from atomic scale characterization to improved devices"
Energy Materials Nanotechnology (EMN) Fall meeting
Orlando FL (USA), 2013

2014

F. CALLE et al
"Graphene for Energy Storage"
NanoSpain 2014
Madrid (Spain), 2014

E. CALLEJA et al
"MBE Selective Area Growth nanostructures for core-shell light emitters and semi-polar pseudo substrates"
Nanowire Materials and Integrated Photonics, IEEE Photonics Society
Montreal (Canada), 2014

E. CALLEJA et al
"MBE Selective Area Growth of III-Nitride nanostructures: from nanoLEDs to pseudo substrates"
SPIE Photonics West Conference
San Francisco (USA), 2014

E. CALLEJA et al
"Ordered III-Nitride nanostructures for core-shell light emitters and semi-polar pseudo substrates"
Int. Symposium on Compound Semiconductors (ISCS 2014)
Montpellier (France), 2014

E. CALLEJA et al
"Selective Area Growth of III-Nitride nanostructures: from nanoLEDs to pseudo substrates "
Sino-German Workshop on III-V Materials & Devices at Nanometer Scale
Berlin (Alemania), 2014

E. CALLEJA et al
"Selective Area Growth of III-Nitride nanostructures: from nanoLEDs to pseudo substrates"
Nano and Giga Challenges in Electronics, Photonics and Renewable Energy from Materials to Devices to Systems Architecture Symposium, NGC2014
Arizona (USA), 2014

E. CALLEJA et al
"Selective Growth by MBE of InGaN/GaN Nanostructures on Polar and Semipolar Substrates "
18th. Int. Conference on MBE
Flagstaff (USA), 2014

M.A. SANCHEZ-GARCIA et al
"Advances on MBE Selective Area Growth of III-Nitride nanostructures: from nanoLEDs to pseudo substrates"
Int. Workshop on Nitride Semiconductors (IWN2014)
Wroclaw (Polonia), 2014

8.4 Ph.D. Thesis

Title: ***“Desarrollo de dispositivos optoelectrónicos mediante crecimiento por MBE y caracterización de nanoestructuras de punto cuántico basadas en (Ga,In)(As,N)”***
Author: Raquel Gargallo Caballero
Director: Álvaro de Guzmán Fernández
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2010
Grade: Sobresaliente “Cum Laude”

Title: ***“GaAs-based quantum well and quantum dot light-emitting diodes and lasers for 1.3 and 1.55 µm emission”***
Author: Miguel Montes Bajo
Director: Adrián Hierro Cano
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2010
Grade: Sobresaliente “Cum Laude” con Doctorado Europeo

Title: ***“Contribución al desarrollo tecnológico de transistores HEMT de AlGaN/GaN”***
Author: María Fátima Romero Rojo
Director/s: Elías Muñoz Merino & Ana Jiménez
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2010
Grade: Sobresaliente “Cum Laude”

Title: ***“Structural And Compositional Characterization Of Wide Bandgap Semiconductor Heterostructures by Ion Beam Analysis”***
Author: Andrés Redondo Cubero
Director/s: Elías Muñoz Merino & Raul Gago
University: University Autónoma de Madrid, 2010
Grade: Sobresaliente “Cum Laude”

Title: ***“Contribución al desarrollo y caracterización de fotodetectores avanzados basados en nitruros del grupo III”***
Author: Álvaro Navarro Tobar
Director/s: Elías Muñoz Merino
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2011
Grade: Sobresaliente “Cum Laude”

Title: ***“Crecimiento, fabricación y caracterización de heteroestructuras y nanocolumnas ordenadas basadas en nitruros del grupo III para aplicaciones sensoras”***
Author: Ana Bengoechea Encabo
Director/s: Miguel Ángel Sánchez-García
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2012
Grade: Sobresaliente

Title: ***“Bloques constituyentes de microcavidades planares de nitruros-III crecidos por epitaxia de haces moleculares”***
Author: Zarko Gacevic
Director/s: Enrique Calleja García
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2012
Grade: Sobresaliente “Cum Laude”. Doctorado Internacional

Title: ***"Transporte dependiente de espín en estructuras de Magnetorresistencia gigante con capas delgadas de Gadolinio''***
Author: Miguel Romera Rabasa
Director: José Luis Prieto Martín
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2012
Grade: Sobresaliente "Cum Laude"

Title: "***Electrodeposicion de nanohilos magneticos: aleaciones de FeNi y oxidos de hierro y de cobalto***"
Author: Angela Llavona Serrano
Director/s: María del Carmen Sánchez Trujillo & Lucas Pérez García
University: University Complutense de Madrid, E.T.S. Ing. de Telecomunicación, 2012
Grade: Sobresaliente "Cum Laude"

Title: ***"Ultra-High frequency thin film SAW devices"***
Author: Juan Gabriel Rodríguez Madrid
Director/s: Fernando Calle Gómez & Gonzalo Fuentes Iriarte
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2013
Grade: Apto "Cum Laude"

Title: ***"Properties and applications of high electron density structures based on InN and related compounds"***
Author: Tommaso Brazzini
Director/s: Fernando Calle Gómez
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2013
Grade: Sobresaliente (Doctorado Internacional-PhD Degree with International Honourable Mention)

Title: ***"Fotodiodos basados en (Zn,Mg)O para la detección de luz ultravioleta"***
Author: Gema Tabares Jiménez
Director/s: Adrian Hierro Cano
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2014
Grade: Sobresaliente "Cum Laude". Doctorado Internacional

Title: ***"Movimiento de paredes de dominio magnético en nanohilos con defectos controlados"***
Author: Johanna Akerman
Director/s: Jose Luis Prieto Martín
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2014
Grade: Sobresaliente "Cum Laude". Doctorado Internacional

8.5 B.Sc. Thesis

2010

Title: **"Caracterización de puntos cuánticos de InAs/GaAsSb y su aplicación en dispositivos emisores para comunicaciones ópticas**"
Author: Miguel del Moral Ortega
Director: José María Ulloa Herrero
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2010
Grade: Sobresaliente, 10 p.

2012

Title: **Implementation of a Deep Level Transient Spectroscopy System"**
Author: Alejandro Kurtz de Griñó
Director: Adrián Hierro Cano
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicación, 2012
Grade: Sobresaliente, 10 p.

Title: **"A characterization of nanohole grating refractive index sensors for biosensing applications"**
Author: Alyssa Bellingham
Director/s: Carlos Angulo Barrios (UPM) / Adam Fontecchio (Drexel University)
University: Drexel University (USA)/Politecnico di Milano (Italy) Dpt. Electrical and Computer Engineering (Drexel University) /Universidad Politécnica de Madrid: EAGLES Program
Grade: Apto.

Title: **"An integrated optical waveguide biomimetic sensor based on a molecularly imprinted polymer: material characterization and design"**
Author: Martina Francesca
Director/s: Carlos Angulo Barrios (UPM) / Marco Bianchessi (Politecnico di Milano)
University: Politecnico di Milano (Italia). Scuola di Ingegneria dell´Informazione (Politecnico di Milano / Universidad Politécnica de Madrid: ERASMUS Program.
Grade: Apto.

2013

Title: **"Síntesis y caracterización de nuevos copolímeros lineales para la fabricación de nanomateriales selectivos mediante fotolitografía y litografía electrónica"**
Author: Sergio Carrasco Garrido
Director/s: Carlos Angulo Barrios (UPM) / Fernando Navarro Villoslada (UCM
University: Universidad Complutense de Madrid (UCM). Facultad de Ciencias Físicas/Universidad Politécnica de Madrid: Campus de Excelencia Internacional (CEI) Moncloa, 2013
Grade: Matrícula de Honor. 10 p.

Title: **"Graphene for flexible devices"**
Author: Tamara Valero Baquero
Director: Fernando Calle Gómez / Javier Martínez Rodrigo
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2013
Grade: Notable. 8 p.

2014

Title: **“Fabricación de nanocolumnas ordenadas de Nitruros-III: evolución morfológica y propiedades ópticas”**
Author: Daniel Gómez Sánchez
Director/s: Zarko Gacevic (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: Matrícula de Honor. 10 p.

Title: **“Caracterización óptica de puntos cuánticos de InAs/GaAs con capping modificado y aplicación en dispositivos emisores de luz”**
Author: Sergio Catalán Gómez
Director/s: Jose María Ulloa (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: 9 (Sobresaliente)

Title: **“Development of a Method for Electrical Characterization of CVD Graphene”**
Author: Thorben Casper
Director/s: Fernando Calle Gómez / Alberto Boscá (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicaciones, 2014
Grade: 9.5 (Sobresaliente)

Title: **“Graphene oxide reduction by laser scribing”**
Author: Antonio Ladrón de Guevara
Director/s: Javier Martínez / Fernando Calle (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Telecomunicaciones, 2014
Grade: 10 p. (Matrícula de Honor)

Title: **“Caracterización de dispositivos magnéticos para la aplicación en redes neuronales y sistemas neuromórficos”**
Author: Irene Bernal Pérez
Director/s: José Luis Prieto, Manuel Muñoz Sánchez (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: 7 p.

Title: **“Distribución de corriente y temperatura en nanohilos ferromagnéticos para aplicaciones en memorias magnéticas alternativas”**
Author: Irene Bernal Pérez
Director/s: José Luis Prieto (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: 9 p.

Title: **“Supercapacitor Electrodes based on Graphene Foam-Polyaniline Nanocomposites”**
Author: Pietro Bonato
Director/s: Roman Sordan, Jorge Pedrós (UPM)
University: Corso de Laurea Magistrale in Ingegneria Fisica, Scuola di Ingegneria Industriale e dell'Informazione, Politecnico di Milano (Italia), 2014
Grade: 110 e lode (Sobresaliente Cum Laude)

Title: **“Fabricación de Grafeno Monocapa mediante Depósito Químico en Fase Vapor en Capas de Cobre sobre Silicio”**
Author: André Pérez Alonso
Director/s: Jorge Pedrós (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: Sobresaliente

Title: **“Funcionalización de Espumas de Grafeno con Polipirrol y su Uso como Electrodos en Supercondensadores”**
Author: David Sánchez Serrano
Director/s: Jorge Pedrós (UPM)
University: University Politécnica de Madrid, E.T.S. Ing. de Caminos, Canales y Puertos, 2014
Grade: Sobresaliente

8.6 Patents

Inventors: José Luis Prieto, Claudio Aroca, Andrés Ruiz, Luis Borrel, Manuel Fernández, Javier Gamo, Paloma Varela
Title: ***"Optically variable label based on magnetic columns"***
Number of Request: P201030960
Country of Priority Spain
Date of Priority: 2010
Entity Holding: Real Casa de la Moneda y Timbre
Country of to which it has spread: Spain

Inventors: Thomas Maike, Bruno Johannes Ehrsnsperger, Alessandra Massa, Manuel Laso, Birgit Wirtz, Roland Engel
Title: ***"Laminate absorbent core for use absorbent articles"***
Number of Request: 11169519 3- 1217
Country of Priority Germany
Date of Priority: 2011
Entity Holding: The Procter & Gamble Company
Country of to which it has spread: European Union

Inventors: Thomas Maike, Bruno Johannes Ehrsnsperger, Alessandra Massa, Manuel Laso, Birgit Wirtz, Roland Engel
Title: ***"Nanoparticles Absorbent Cores"***
Number of Request: 11169514.4
Country of Priority Germany
Date of Priority: 2011
Entity Holding: The Procter & Gamble Company
Country of to which it has spread: European Union

Inventors: Gonzalo Fuentes
Title: ***"Método de fabricación de sustratos de circuitos integrados basados en tecnología CMOS"***
Number of Request: ES2346396
Country of Priority Spain
Date of Priority: 2011
Entity Holding: Universidad Politécnica de Madrid
Country of to which it has spread: Spain

Inventors: Martin Strassburg, Enrique Calleja, Steven Albert, Ana María Bengoechea, Miguel Ángel Sánchez- García, Martin Mandl, Christopher Kölper
Title: ***"Light-emitting diode chip"***
Number of Request: 12151946.6 - 1564
Country of Priority Germany
Date of Priority: 2012
Entity Holding: OSRAM Opto Semiconductors GmbH
Country of to which it has spread: European Union

Inventors: Alberto Boscá, Jorge Pedrós, Javier Martínez, Fernando Calle, Tomás Palacios
Title: ***"Procedimiento de transferencia de nanocapas y aparato de realización del mismo"***
Number of Request: P201331701
Country of Priority Spain
Date of Priority: 2013
Entity Holding: Universidad Politécnica de Madrid, Massachusetts Institute of Technology
Country of to which it has spread: Spain

Inventors: Claudio Aroca, Pedro Cobos, Ignacio De Mendizábal, Marina Pérez
Title: ***"Procedimiento de medida de parámetros magnéticos y de los armónicos temporales tanto en fase como en cuadratura del momento magnético de pequeñas muestras excitadas con campos magnéticos alternos o continuos y dispositivo para la puesta en práctica del procedimiento"***
Number of Request: P201331745
Country of Priority Spain
Date of Priority: 2013
Entity Holding: Universidad Politécnica de Madrid
Country of to which it has spread: Spain

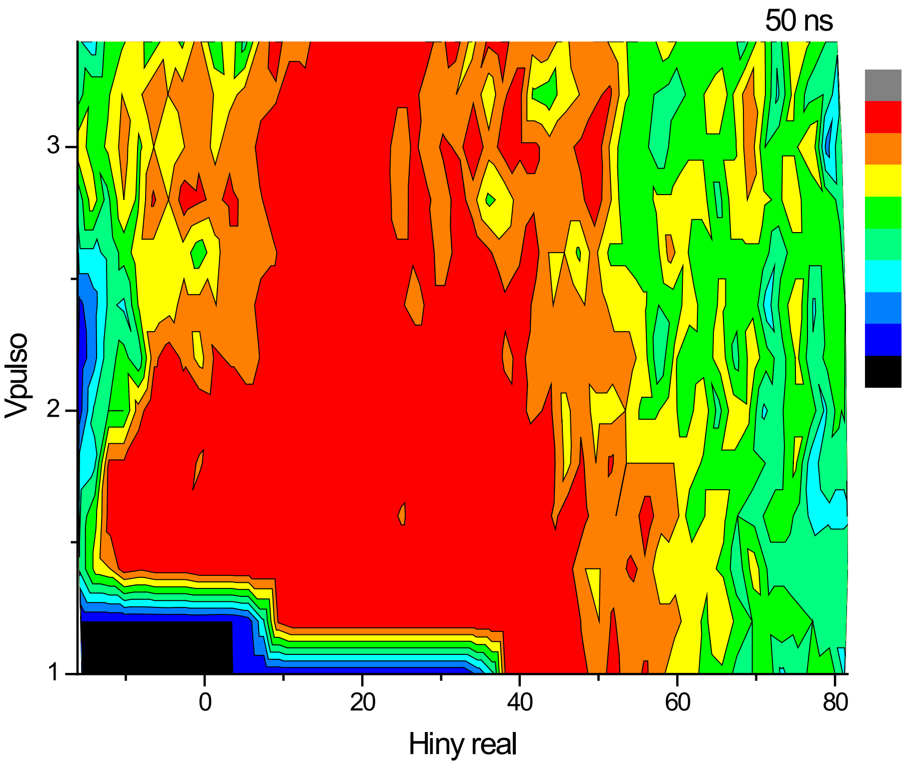
Inventors: Claudio Aroca, Pedro Cobos
Title: ***"Sistema antifraude para detectar la aplicación de campos magnéticos no deseados a dispositivos sensibles"***
Number of Request: P201331641
Country of Priority Spain
Date of Priority: 2013
Entity Holding: Universidad Politécnica de Madrid
Country of to which it has spread: Spain

Inventors: Claudio Aroca, Pedro Cobos, Marina Pérez, Jesús Martínez-Ruano
Title: ***"Sistema de detección e identificación de vehículos rodados"***
Number of Request: P201331863
Country of Priority Spain
Date of Priority: 2013
Entity Holding: Universidad Politécnica de Madrid
Country of to which it has spread: Spain

Inventors: Carlos Angulo, Maria Cruz Moreno, Sergio Carrasco, Víctor Canalejas, Fernando Navarro
Title: ***"Método de obtención de una estructura de polímero de impronta molecular (MIP)"***
Number of Request: P2013309477
Country of Priority Spain
Date of Priority: 2013
Entity Holding: Universidad Politécnica de Madrid and Universidad Complutense de Madrid
Country of to which it has spread: Spain

Inventors: Thomas Maike, Bruno Johannes Ehrsnsperger, Alessandra Massa, Manuel Laso, Birgit Wirtz, Roland Engel
Title: ***"Laminate absorbent core for use absorbent articles"***
Number of Request: PTO/AIA/01 (06-12), Approved for use through 01/31/2014. OMB 06510032
Country of Priority USA
Date of Priority: 2014
Entity Holding: The Procter & Gamble Company
Country of to which it has spread: USA

9 R&D COLLABORATIONS, SERVICES AND SEMINARS



Probability map for the creation of a magnetic domain wall in a permalloy nanowire, with a short electrical pulse flowing through a current line on top. There are regions of probability one, even for zero magnetic field, which is very important for the implementation of future magnetic memories.

9.1 International Scientific Collaborations

- Air Force Research Laboratory, (USA)
- Commissariat à l'Energie Atomique, Grenoble (France)
- CRHEA-CNRS, Valbonne (France)
- Ecole Politechnique Federale Lausanne (Switzerland)
- Fraunhofer IAF Institute, Freibourg (Germany)
- High Pressure Research Center, Warsaw (Poland)
- III-V Lab, Paris (France)
- Massachusetts Institute of Technologies, Boston (USA)
- National Institute of Standards and Technology, Washington (USA)
- Naval Research Labs, Washington DC (USA)
- Ohio State University (USA)
- OSRAM gmbH, Regensburg (Germany)
- Paul Drude Institute, Berlin (Germany)
- Ritsumeikan University, Shiga (Japan)
- Shizuoka University (Japan)
- Technical University of Braunschweig (Germany)
- Technische Universiteit Eindhoven (The Netherlands)
- Université Montpellier 2, Montpellier (France)
- Université Paris-Sud, Orsay (France)
- University of California, Berkeley (USA)
- University of Cambridge (UK)
- University of Cardiff (UK)
- University of Fukui (Japan)
- University of Giessen (Germany)
- University of Sheffield (UK)
- University of Strathclyde, Glasgow (Scotland)
- University of Warwick, Coventry (UK)

9.2 National Scientific Collaborations

- Centro de Electrónica Industrial (UPM)
- Centro de Tecnología Biomédica (UPM)
- Centro Español de Metrología, Madrid
- Centro Láser (UPM)
- CIEMAT, Madrid
- Fábrica Nacional de Moneda y Timbre, Madrid
- INDRA, Sistemas, S.A., Madrid
- Instituto de Ciencia de Materiales, ICMM-CSIC, Madrid
- Instituto de Microelectrónica, IMB-CSIC, Barcelona
- Instituto de Microelectrónica, IMM-CSIC, Madrid
- Metro de Madrid
- Universidad Autónoma de Madrid
- Universidad Carlos III, Madrid
- Universidad Complutense de Madrid
- Universidad de Alcalá de Henares
- Universidad de Barcelona, Departamento de Electrónica
- Universidad de Cádiz
- Universidad de Salamanca
- Universidad de Valencia
- Universidad Rey Juan Carlos, Madrid
- Universidad Politécnica de Valencia

9.3 External Services (ICTS)

The services offered by CT-ISOM relate to technologies available at the Institute:

- **SAMPLE GROWTH**
    - Joule metallization (Au, AuGe, AuZn, Ni, etc)
    - e-beam metallization (Au, Pt, Ti, Al, etc.)
    - Chemical Vapour Deposition (CVD) for insulators (Si-O-N systems)
    - Sputtering for magnetic materials (Fe, Ni, Co, FeNi, etc.)
    - Molecular Beam Epitaxy (MBE) for semiconductors (AlGaInAs and AlGaInN materials systems)
    - Electrodeposition of Au, Ni, CoP, etc.
    - Air-bridge contacts fabrication

- **PROCESSING TECHNIQUES**
    - **Lithography**
        - Electron beam lithography (EBL) (resolution > 10 nm)
        - Photolithography (resolution > 1 micron)
        - Colloidal lithography
        - Optical Mask design
    - **Chemical, Thermal and Mechanical Treatment**
        - Cleaning (Organic, acid chemicals...)
        - Polishing (machine and hand)
        - Precission cutting
        - Reactive Ion Etching (RIE)
        - Wet Etching
        - Rapid Thermal Annealing (RTA)
    - **Soldering and packaging**
        - Soldering, TO-5, TO-8, other packaging

- **SAMPLE CHARACTERIZATION**
    - **Optical Characterization (materials)**
        - Photoluminescence at IR-VIS-UV at temperatures within the range 10-300K
        - Electroluminescence
        - FTIRS (600 nm-20 microns)
        - Ellipsometry
    - **Optoelectronic Characterization (structures and devices)**
        - Spectral responsivity of detectors (from 12 microns to 200 nm)
        - Spectral laser emission (from 600 to 1700 nm)
        - Spectral luminescence emission (from 200 nm to 2.5 micros)
        - L-I curves in UV-VIS-IR lasers
    - **Electrical and Magnetical Characterization**
        - Resistivity measurements, room temperature
        - Hall measurements, variable with temperature (100-300K)
        - C-V and I-V measurements (temperature and frequency dependence)
        - Hysteresis cycles for thin films
    - **Microscopic, Morphological and Structural Characterization**
        - Thin film thickness measurements (*Dek-Tak* profiler)
        - Nomarski contrast microscope
        - EDX characterization and morphological measurements by SEM
        - AFM and MFM Characterization
        - X-Ray Diffraction

The Institutions that received services from CT-ISOM during the period 2010-2013 are the following:

2010

- **Facultad de Química-UCM**

Researchers: Dª. Zhenhe Chen (Dª. María Cruz Moreno Bondi)
Research line: Development of difraction arrays in planar structures for the deposition of polimetric materials

- **CNRS-THALES**

Researchers: Dª. Julie Grollier
Research line: Cross-talk effects among magnetic domain walls in nanowires for "racetrack memory" applications

- **Universidad Pública de Navarra**

Researchers: D. Carlos Ruiz Zamarreño
Research Line: Fabrication of metallic deposits on optical fiber
ICMUV

- **Instituto de Ciencia de Materiales de Valencia (ICMUV)**

Researchers: D. José Marqués Hueso (D. Juan Martínez Pastor)
Research Line: Fabrication of active photonic cavities of optimized design in GaAs/InAs technology

- **Instituto de Reconocimiento Molecular y desarrollo tecnológico-UPV**

Researchers: Dª. María José Bañuls Polo
Research Line: Fabrication of SU-8 nanodevicesincorporating bioreceptor

- **Instituto de Ciencia de Materiales de Madrid-CSIC**

Researchers: D. Oscar de Abril
Research Line: Study of the dipolar magnetic coupling in arrays of nanowires by MFM with variable field application

- **Centro tecnológico IK4-Tekniker**

Researchers: D. Aritz Juarros Lascurain
Research Line: Fabrication of a silicon stamp with four 1D gratings of periods 363, 370, 377 and 384 nm for solid states organic lasers with distributed feedback

- **Paul-Drude-Institut für Festkörperelektronik (PDI)**

Researchers: Dª. Esperanza Luna
Research Line: Study of the properties of the interfaces in heterostructures of GaAs/AlGaAs by TEM

- **Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)**

Researchers: Dª. Susana María Fernández Ruano
Research Line: Thickness determination in metallic layers deposited on amorphous silicon

- **Università di Pavía**

Researchers: D. Francesco Rosella (D. Vittorio Bellini)
Research Line: Deposition of nano-electrodes on Co-filled multi wall carbon nanotubes for magneto-transport experiments

- **Instituto Tecnológico de Europa Central (CEIT)**

Researchers: Dª. Irene Castro Hurtado (Dª. Gemma García Mancayo)
Research Line: Studies of the interaction of formaldehico and DMMP with NiO, Au/NiO and WO3 by FTIR

- **Instituto de Ciencia de Materiales de Madrid-CSIC**

Researchers: Dª. Beatriz Galiana Blanco
Research Line: Nanostructuring of GaAs and Si substrates for the lateral growth by MBE

- **Escuela Técnica Superior de Ingenieros Navales de la UPM**

Researchers: Dª. Teresa Leo Mena
Research Line: Carbon cloth coated with platinum and platinum / ruthenium for operation in fuel cell electrodes

- **Ciencia y Tecnologías Físicas (CETEF-CSIC)**

Researchers: D. Tomás Gómez Álvarez-Arenas
Research Line: Metallization of ferroelectret thin films

- **Instituto de Ciencia de Materiales de Madrid-CSIC**

Researchers: Dª. Miriam Yuste (D. Ramón Escobar)
Research Line: RTA heat treatment of ZnO samples deposited by reactive magnetron sputtering on Si substrates.

- **Universitat Politecnica de Catalunya**

Researchers: Dª. Sandra Bermejo
Research Line: Silicon samples thinning

- **Instituto de Reconocimiento Molecular y desarrollo tecnológico-UPV**

Researchers: Dª. Tania Arnandis Chover (Dª. María José Bañuls)
Research Line: Fabrication of nanodevices based SU-8 incorporating a bioreceptor

- **Cavendish Laboratory. University of Cambridge**

Researchers: D. Jorge Pedrós
Research Line: Measurement of SAW devices in HEMT structures of GaN and Zn = / GaAs in the range 2-10 GHz 2010

- **Universidad Rey Juan Carlos Madrid**

Researchers: Dª. Belén Arredondo Conchillo
Research Line: Photolithography for defining the anode of light emitting diodes based on organic material

- **Instituto de Energía Solar de la UPM**

Researchers: D. Manuel Joao Mendes (D. Ignacio Tobías Galicia)
Research Line: Embedment of Metal Nanoparticles in Si and GaAs for Plasmonic Absorption Enchancemente in Solar Cells.

- **Universidad Rey Juan Carlos Madrid**

Researchers: Dª. Beatriz Romero Herrero
Research Line: Photolithography for defining the anode of solar cells based on organic material

- **Facultad de Biológicas-UCM**

Researchers: D. Miquel Arroyo Sánchez
Research Line: Magnetic characterization of chitosan beads crosslinked with magnetite

- **Instituto de Energía Solar de la UPM**

Researchers: D. Alexander Virgil Mellor (D. Ignacio Tobías Galicia)
Research Line: Diffraction gratings for light trapping in solar cells

- **Universidad Carlos III de Madrid**

Researchers: Dª. Virginia Urruchi del Pozo
Research Line: Photolithography of rows for display manufacturing

- **Universidad de Salamanca**

Researchers: Dª. Beatriz Martín García (Dª. Mercedes Velázquez Salicio)
Research Line: Graphene electronic nanodevices obtained by chemical methods

- **Centro Láser-UPM**

Researchers: D. Francisco Javier Sanza Gutiérrez (Dª. María Fé Laguna)
Research Line: Fabrication of micro and sub-micron wells for metrology and traceability of liquid volumes by advanced optical metrology techniques

- **Universidad de Valladolid**

Researchers: Dª. Marta Fraile Baños (D. José Antonio Saja)
Research Line: AFM Characterization of Thin Films of Bisfatalocianinas, Araquidio acid and enzyme

- **Instituto de Ciencia de Materiales de Madrid-CSIC**

Researchers: Dª. Beatriz Galiana Blanco
Research Line: Effect of H in the electrical properties of GaAs grown by MBE

- **Facultad de Física-UCM**

Researchers: Dª. Rosa Weigand Talavera
Research Line: Development of detectors based in SiO2 for the detection of ultrafast UV pulses by intensometric autocorrelation

- **Universidad Carlos III de Madrid**

Researchers: D. Guillermo Carpintero del Barrio
Research Line: Schottky Diode Assembly made within European project iPHOS on antennas manufactured in the UC3M

- **Universidad de Salamanca**

Researchers: D. Cayetano Sánchez-Fabrés (D. Enrique Díez Fernández)
Research Line: Electronic nanodevices on suspended graphene

- **Centro Nacional de Sanidad Ambiental- ISCIII**

Researchers: Dª. Aránzazu Sanchis Otero
Research Line: Microelectrodes for dielectric characterización of biological cells using electrokinetic

2011

- **Universidad de Valladolid**

Researchers: D. Felipe Silva Bellucci (D. José Antonio Saja)
Research Line: Preparation and characterization of multifunctional nanocomposites obtained with paramagnetic nanoparticles and ferroelectric films included in natural rubber

- **Centro tecnológico IK4-Tekniker**

Researchers: D. Aritz Juarros Lascurain
Research Line: Fabrication of a silicon stamp with four 1D gratings of periods 363, 370, 377 and 384 nm for solid states organic lasers with distributed feedback

- **Universidad de Salamanca**

Researchers: D. Cayetano Sánchez-Fabrés (D. Enrique Díez Fernández)
Research Line: Transfer of graphene grown by CVD: nanotransistors

- **Universidad Autónoma de Madrid**

Researchers: D. David Herranz Aragoncillo (D. Farkhad Aliev)
Research Line: Development of circular samples of permalloy contracted by wave guides

- **Facultad de Física-UCM**

Researchers: D. Mirko Rocci (D. Jacobo Santamaría)
Research Line: Ferromagnetic oxides nanowires with Colossal Magnetoresistance for injection of spines

- **Universitat Politecnica de Catalunya**

Researchers: Dª. Sandra Bermejo
Research Line: Polising of silicon samples until thinned to 50 microns

- **Facultad de Biológicas-UCM**

Researchers: D. Miquel Arroyo Sánchez
Research Line: Magnetic characterization of chitosan beads crosslinked with magnetite (Fe_3O_4)

- **Universidad Autónoma de Barcelona**

Researchers: Dª. Aïda Varea Espelt (D. Jordi Sort Viñas)
Research Line: Nanostructure fabrication based on silicon substrate using electron beam lithography for subsequent electrodeposition of magnetically soft and hard metallic layers

- **Instituto de Estructura de la Materia-CSIC**

Researchers: D. Tiberio Ezquerra Sanz
Research Line: Fabrication of Silicon nano-templates for Soft Lithography

- **Facultad de Física-UCM**

Researchers: Dª. Rosa Weigand Talavera
Research Line: Deposition of Graphene on SiO2 substrate and multilayer dielectric mirrors

- **University of Essex**

Researchers: D. Ernesto Momox-Beristain (D. N. Balkan)
Researcher Line: AlN/GaN simple and Hall bar Structures

- **Instituto Tecnológico de Europa Central (CEIT)**

Researchers: Dª. María del Carmen Fuentes Dubra (Dª. Isabel Ayerdi Olaizola)
Research Line: Pt metallization on flexible polymer substrate using e-beam evaporation

- **Universidad Rey Juan Carlos Madrid**

Researchers: D. Gonzalo del Pozo Melero (Dª. Belén Arredondo Conchillo)
Research Line: Photolithography for defining the anode of solar cells based on organic materials (II)

- **IMDEA-Nanociencias**

Researchers: D. Juan Cabanillas González
Research Line: Photolithography of rows for the fabrication of array of organic solar cells

- **Universidad de Salamanca**

Researchers: D. Cayetano Sánchez-Fabrés (D. Enrique Díez Fernández)
Research Line: Nanodevices in graphene on hexagonal boron nitride

- **Centro de Astrobiología- CSIC-INTA**

Researchers: D. Juan Bueno López
Research Line: Manufacturing of kinetic inductance superconducting detectors based on titanium nitride-TiNKIDs

- **Departamento de Electromagnetismo y Teoría de Circuitos-ETSIT-UPM**

Researchers: D. Carlos A. Leal Sevillano (D. Jesús María Rebollar)
Research Line: Test of new resin SU-8 for micromachining devices in the terahertz band

- **Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT)**

Researchers: D. Alberto Sáez Maderuelo
Research Line: Creating a grid on a sample of austenitic stainless steel by electron beam lithography to study the effect of plastic deformation in the material

2012

- **Instituto de Diseño para la Fabricación y Producción Automatizada (Universidad Politécnica de Valencia)**

Researchers: Dª. Paula Cembrero Coca (Dª. Marián Abellán)
Research Line: Heat treatment by RTA and electrical characterization of thin films of PbSe / Si

- **Universidad de Salamanca**

Researchers: D. Cayetano Sánchez-Fabrés (D. Enrique Díez Fernández)
Research Line: Graphene Transistor with angled doors

9.4 Stays of ISOM members in foreign Institutions

2010

Dª. Gema Tabares “Department of Electrical and Computer Engineering, Ohio State University” Ohio State	USA	12 week/s
Dr. N. C Karayiannis “Harbin Institute of Technology (HIT)” Harbin	China	2 week/s
D. Miguel Romera Rabasa “Unité Mixte de Physique CNRS/Thale” París	France	4 week/s

2011

D. Tommaso Brazzini “Warwich University” Conventry	United Kingdom	4 week/s
D. Miguel Romera Rabasa “Unité Mixte de Physique CNRS/Thale” Paris	France	4 week/s
Dr. Marko Tadjer “Naval Research Laboratory” Washington DC	USA	8 week/s
Dra. María Fátima Romero Rojo Otto-von-Guericke-Universitat in Magdeburg Magdeburg	Germany	60 week/s

2012

Dr. Marko Tadjer “Naval Research Laboratory” Washington D.C	USA	16 week/s
Alberto Boscá Mojena “Cambridge,MA” MIT, EECS laboratory	USA	14 week/s
D. Tommaso Brazzini “Lawrence Berkeley National Laboratory” Berkeley, California	USA	8 week/s
Dr. Alvaro de Guzmán Fernández “Paul Drude Institut” Berlín	Germany	24 week/s
Dª. María José Milla “Paul Drude Institut” Berlín	Germany	16 week/s

D. Manuel López Ponce		
"Laboratoire Charles Coulomb - CNRS, Universite Montpellier 2"		
Montpellier	*France*	*4 week/s*
Dr. José Luis Prieto Martín		
"Cambridge University"		
Londres	*United Kingdom*	*24 week/s*

2013

D. Manuel López Ponce		
"Research Institute of Electronics, Shizuoka University"		
Shizuoka	*Japan*	*10 week/s*
D. Manuel López Ponce		
"Laboratoire Charles Coulomb - CNRS, Universite Montpellier 2"		
Montpellier	*France*	*3 week/s*

2014

D. Alejandro Kurtz		
"Ohio State University"		
Columbus, Ohio	*USA*	*12 week/s*
Dª. Gema Tabares		
"CRHEA-CNRS"		
Valbonne	*France*	*8 week/s*

9.5 Program Committees Membership

2010

Fernando Calle
Member of the Steering Committee
34th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´10
Darmstadt (Germany), 2010

Fernando Calle
Member of the Steering Committee
19th European Heterostructure Technology Workshop, HETECH'10
Fodele (Greece), 2010

Fernando Calle
Member of the Organizing Committee
Workshop on InN Technologies (Rainbow)
Madrid (Spain), 2010

Enrique Calleja
Chairman in Conferences Sessions
16th International Conference on Molecular Beam Epitaxy
Berlin (Germany) 2010

Enrique Calleja
Chairman in Conferences Sessions
International Workshop on Nitride Semiconductors, IWNS-2010
Tampa, Florida (USA) 2010

Enrique Calleja
Conference/Program Chairman:
Int. Workshop on Nitride Semiconductors (IWNS)
Tampa, Florida (USA), 2010 (Co-Chair for the topical session G "Nanostructures")

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
16th Int. Conference on Molecular Beam Epitaxy
Berlin (Germany), 2010

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
International Workshop on Nitride Semiconductors, IWNS2010
Tampa, Florida, (USA), 2010

Elías Muñoz
Member of the International Advisory Committee
ISSLED 2010, Beijing (China), 2010

Elías Muñoz
Member of the International Advisory Committee
WOCSDICE 2010
Darmstadt (Germany), 2010

Elías Muñoz
Member of the International Advisory Committee
International Workshop on Nitrides
Tampa (USA), 2010

Miguel Ángel Sánchez-García
Chairman
Workshop on InN Technologies (Rainbow) , Madrid (Spain), 2010

2011

Fernando Calle
Member of the Technical Committee
8ª Conferencia de Dispositivos Electrónicos
Palma de Mallorca (Spain), 2011

Fernando Calle
Member of the Steering Committee
35th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´11
Catania (Italy), 2011

Fernando Calle
Member of the Steering Committee
20th European Heterostructure Technology Workshop, HETECH 2011
Lille (France), 2011

Enrique Calleja
Chairman in Conferences Sessions
9th International Conference on Nitride Semiconductors, ICNS-9
Glasgow, Scottland (United Kingdom), 2011

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
22nd Congress and General Assembly of the International Union of Crystallography. Symp. on "Wide Band Semiconductor and other Crystals Used in Optoelectronics"
Madrid (Spain), 2011

Álvaro de Guzmán Fernández
Member of Local Organizing Committee
Workshop on Frontier Photonic and Electronic Materials and Devices, 2011 German-Japanese-Spanish Joint Workshop
Granada (Spain), 2011

Adrián Hierro
Member of Local Organizing Committee
Workshop on Frontier Photonic and Electronic Materials and Devices, 2011 German-Japanese-Spanish Joint Workshop
Granada (Spain), 2011

Elías Muñoz
Chairman of the Organizing Committee
2011 Japanese-Spanish-German Joint Workshop on Advanced Semiconductor
Optoelectronic Materials Devices
Granada (Spain), 2011

Elías Muñoz
Member of Technical Committee of the International Program Conference
International Symposium on Compound Semiconductors
Berlín (Germany), 2011

Elías Muñoz
Member of the International Advisory Committee
WOCSDICE 2011
Catania (Italy), 2011

Elías Muñoz
Member of the International Advisory Committee
9th Int Conf. on Nitride Semiconductors (ICNS)
Glasgow (United Kingdom), 2011

Miguel Ángel Sánchez-García
Member of Local Organizing Committee
Workshop on Frontier Photonic and Electronic Materials and Devices, 2011 German-Japanese-Spanish Joint Workshop
Granada (Spain), 2011

2012

Fernando Calle
Member of the Steering Committee
36th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´12
Porquerolles (France), 2012

Fernando Calle
Member of the Steering Committee
21th European Heterostructure Technology Workshop, HETECH 2012
Barcelona (Spain), 2012

Fernando Calle
Co-chairman of Organizing Committee
21st European Heterostructure Technology Workshop, HETECH 2012
Barcelona (Spain), 2012

Enrique Calleja
Chairman in Conferences Sessions
Int. Workshop on Nitride Semiconductors, Plenary session, IWN2012
Sapporo (Japan), 2012

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
ICPS31 "International Conference on the Physics of Semiconductors"
Zurich (Switzerland), 2012

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
9th Int. Symposium on Semiconductor Light Emitting Devices (ISSLED)
Berlin (Germany), 2012

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
11th Expert Evaluation &Control of Compound Semiconductor Materials & Technologies (EXMATEC)
Porquerolles (France), 2012

Javier Martínez
Member of the Local Organization
21th European Heterostructure Technology Workshop, HETECH 2012
Barcelona (Spain), 2012

Elías Muñoz
Co- Chairman of the Organizing Committee
2012 Japanese-Spanish-German Joint Workshop on Advanced Semiconductor Optoelectronic Materials Devices
Berlin (Germany), 2012

Elías Muñoz
Member of the International Advisory Committee (Europe)
Internacional Workshop on Nitrides IWN 2012
Sapporo (Japan), 2012

Jorge Pedrós
Member of the Local Organization
21th European Heterostructure Technology Workshop, HETECH 2012
Barcelona (Spain), 2012

2013

Fernando Calle
Director
Curso de Verano UPM Emerging Application of Graphene. ETSI de Telecomunicación. UPM. Madrid, 15 y 16 de julio, 2013
Madrid (Spain), 2013

Fernando Calle
Member of the Technical Committee
9ª Conferencia de Dispositivos Electrónicos
Valladolid (Spain), 2013

Fernando Calle
Member of the Steering Committee
37th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´13
Warnemunde (Germany), 2013

Fernando Calle
Member of the Steering Committee
22th European Heterostructure Technology Workshop, HETECH 2013
Glasgow (United Kingdom), 2013

Fernando Calle
Member of the Technical Committee
1er Congreso Nacional I+D en Defensa y Seguridad DESEi+d 2013
Madrid (Spain), 2013

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
E-MRS Spring meeting: "Functional Nanowires: Synthesis, Characterization and Applications"
Strasbourg (France), 2013

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
Int. Conference on Nitride Semiconductors ICNS10
Washington, DC (USA), 2013

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
17th Euro-MBE Conference
Levi (Finland), 2013.

Enrique Calleja
Session Chairman
International Nano-Optoelectronics Workshop (iNOW2013)
Cargese, Corsica (France), 2013

Javier Martínez
Secretary
Curso de Verano UPM Emerging Application of Graphene. ETSI de Telecomunicación. UPM
Madrid (Spain), 2013

Elías Muñoz
Member of the International Advisory Committee (Europe)
10th Int Conf. on Nitride Semiconductors (ICNS)
Washington (USA), 2013

Jorge Pedrós
Secretary
Curso de Verano UPM Emerging Application of Graphene. ETSI de Telecomunicación. UPM
Madrid (Spain), 2013

2014

Fernando Calle
Member of the Steering Committee
38th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´14
Delphi (Greece), 2014

Elías Muñoz
Member of the Steering Committee
38th Workshop on Compound Semiconductors and Integrated Circuits, WOCSDICE´14
Delphi (Greece), 2014

Fernando Calle
Member of the Technical Committee
10ª Conferencia de Dispositivos Electrónicos
Aranjuez (Spain), 2014

Enrique Calleja
Member of the Advisory Committee
10ª Conferencia de Dispositivos Electrónicos
Aranjuez (Spain), 2014

Elías Muñoz
Member of the Advisory Committee
10ª Conferencia de Dispositivos Electrónicos
Aranjuez (Spain), 2014

Fernando Calle
Member of the Steering Committee
23th European Heterostructure Technology Workshop, HETECH 2014
Justus Liebig University Giessen (Germany), 2014

Enrique Calleja
Chairman in Conferences Sessions
Int. Workshop on Nitride Semiconductors, IWN2014
Wroclaw (Poland), 2014

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
10th Int. Symposium on Semiconductor Light Emitting Devices (ISSLED)
National Sun Yat-sen University (Taiwan), 2014

Enrique Calleja
Member of the Organizing Committee
E-MRS Spring meeting: "Challenges for Group III Nitride Semiconductors for Solid State Lighting and Beyond"
Lille (France), 2014

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
Collaborative Conference on Crystal Growth (3CG)
Phuket, Thailand. 2014

Enrique Calleja
Member of Conference Committee (Program and Advisory Boards)
18th Int. Conf. on Molecular Beam Epitaxy,
Flagstaff, Arizona, USA. 2014

9.6 Invited Seminars held at ISOM

2010

Dra. Yolanda Campos
"Multiplicadores de frecuencia MMIC para ondas milimétricas"
Universidad de Extremadura
February 12th, 2010

Dr. Filip Tuomisto
"Positron research group leader Academy Research Fellow"
Department of Applied Physics Aalto University Finland
February 16th, 2010

Prof. Michael E. McHenry
"Nanostructural Evolution in Materials for Use in Ferrofluids and Polymeric Nanocomposite Systems for Biomedical Applications"
Carnegie Mellon University. Materials Science and Engineering
March 5th, 2010

Prof. Katsumi Kishino
"Recent progress in GaN-based nanocolumns and related technology"
Sophia University Tokyo, Japan
March 22nd, 2010

Prof. Kevin O' Grady
"New trends in exchange bias in sputtered polycrystalline films"
University of York
April 12nd, 2010

Dr. Marko Tadjer
"Diamond and Self-heating in AlGaN-GaN HEMTs"
U.S. Naval Research Laboratory and University of Maryland
April 30th, 2010

Prof. Steven A. Ringel
"Spectrum Optimized Solar Cells and Green Light Emitters Using Engineered Si Substrates"
Ohio State University and Institute for Materials Research (IMR), Ohio (USA)
May 7th, 2010

D. José Capilla Osorio
"Técnicas de caracterización de materiales aplicadas al nitruro de aluminio"
Grupo GMME, Departamento de Tecnología Electrónica de la E.T.S.I. Telecomunicación, Universidad Politécnica de Madrid
May 27th, 2010

Dra. Julie Grollier
"Synchronization of spin-transfer nano-oscilators"
Unite Mixte de Physique CNRS-THALES (del grupo de Albert Fert, Nobel 2007)
July 1st, 2010

Prof. Lorenzo Faraone
"Optical MEMS Technologies for Multi-Spectral Infrared Sensors and Arrays"
Microelectronics Research Group, the University of Western, Australia
September 20th, 2010

Dr. Javier Martínez Rodrigo
"Nanohilos de Silicio: Fabricación y Aplicaciones"
Instituto de Microelectrónica de Madrid-CSIC
November 19th, 2010

2011

Prof. Dr. Francisco Guinea
"El grafeno y sus propiedades únicas"
Instituto de Ciencia de Materiales de Madrid, CSIC
February 8th, 2011

Prof. Masaaki Kuzuhara
"III-Nitride FETs on Nitride Substrates"
University of Fukui, Japan
March 14th, 2011

Dra. Lidia Martínez
"New strategy in nanoparticle fabrication. Generation of nanoclusters with adjustable size and chemical composition in UHV"
Instituto de Ciencia de Materiales de Madrid
September 15th, 2011

Dr. Víctor Tapio Rangel Kuoppa
"Resultados de la caracterización eléctrica de los semiconductores GaInAs, GaInNAs, InN y GaN"
Instituto de Semiconductores y Estado Solido de la Universidad Johanes Kepler, Linz, Austria
October 25th, 2011

Prof. Steve A. Ringel
"Challenges of Understanding GaN HEMT Degradation and Reliability and Recent Results"
Ohio State University and Institute for Materials Research (IMR), Ohio, USA
October 26th, 2011

Prof. Sylvie Contreras
"Magnetic Hall sensors based on III-V heterostructures"
Univ. Montpellier 2, Montpellier, France
October 28th, 2011

Prof. Vadim Lebedev
"AlN - nanodiamond based MEMS and NEMS"
Fraunhofer IAF, Friburgo, Germany
December 5th, 2011

Prof. Volker Cimalla
"Chemical sensing with AlGaN/GaN structures"
Fraunhofer IAF, Friburgo, Germany
December 5th, 2011

Dr. Marco Abbarchi
"Spectroscopy of droplet epitaxial GaAs nanoemitters"
Laboratoire Pierre Aigrain, Ecole Normale Superieure, CNRS (UMR 8551), Universite P. et M. Curie, Universite, D.Diderot
December 26th, 2011

2012

Dr. Adam Urbanczyk
"Epitaxial metal nanocrystal-semiconductor quantum dot plasmonic nanostructures"
COBRA Research Institute, Eindhoven University of Technology
January 26th, 2012

Prof. Mircea Dragoman
"Carbon Nanoelectronics for RF Applications"
National Institute of Research and Development in Microtechnology (IMT) in Bucharest, Romania
February 7th, 2012

Prof. Pablo Esquinazi
"Is Graphite the best Graphene? Searching for its intrinsic transport properties"
Head of the Division of Superconductivity and Magnetism, and Dean of Studies for Physics and Meteorology, University of Leipzig, Germany conductivity and Magnetism, University of Leipzig, Germany
February 29th, 2012

Prof. H.L. Hartnagel
"Terahertz Studies towards Fast Imaging"
Fachgruppe Mikrowellenelektronik, Institute for Microwave and Optics Technical University Darmstadt, Darmstadt, Germany
March 28th, 2012

Prof. Steve A. Ringel
"An introduction to photovoltaics"
The Ohio State University and Institute for Materials Research (IMR), Ohio, USA
April 17th, 2012

Prof. Stefano Sanguinetti
"Semiconductor Quantum Nanostructures by Droplet Epitaxy"
Dipartimento di Scienza dei Materiali, Università di Milano Bicocca, Italy
June 7th, 2012

Dr. C. J. B. Ford
"Novel designs for quantum computers using moving quantum dots"
Cavendish Laboratory, University of Cambridge, UK
June 25th, 2012

Dr. Andrés Castellanos-Gómez
"Atomically thin crystals: Beyond grapheme"
Kavli Institute of NanoScience, TU Delft, Netherlands
September 21st, 2012

Prof. Magnus Willander
"Nanostructures and their Applications"
Department of Science and Technology, Linkoping University, Sweden
October 3rd, 2012

2013

Dr. Andrés Redondo-Cubero
"Applications of ion beam techniques for the study of semiconductors: from growth to processing issues"
Instituto Superior Técnico (Technical University of Lisbon, Portugal)
June 14th, 2013

Dr. Benito Alén
"Beyond self-assembly: Advanced fabrication and characterization methods applied to unconventional semiconductor nanostructures"
Instituto de Microelectrónica de Madrid, Centro Nacional de Microelectrónica (CSIC)
July 5th, 2013

D. Wenquan Ma
"Type II InAs/GaSb superlattice infrared photodetectors"
Institute of Semiconductors, Chinese Academy of Sciences, Qinghua East Road A 35, Beijing 100083, China
July 8th, 2013

D. Andrés Castellanos-Gómez
"Nanomechanics and strain engineering in atomically thin MoS2"
Delft University of Technology, 2628 CJ Delft, the Netherlands
October 17th, 2013

2014

Prof. Jiro Temmyo
"ZnO-based and graphene material systems for green devices"
Shizuoka University (Hamamatsu, Japón)
October 10th, 2014

Prof. Chris McConville
"Electronic Structure and Properties of Transparent Conducting Oxide Semiconductors"
Warwick University (UK)
July 7th, 2014

Prof. Durga Basak
"Future of multifunctional nanocrystalline ZnO"
IACS, Calcuta (India)
January 21st, 2014

Prof. Pallab Bhattacharya
"III-Nitride Nanowire Light Sources"
University of Michigan (USA)
June 16th, 2014

Prof. Czeslaw Skierbiszewski
"Nitride laser diodes grown by Plasma Assisted MBE"
Institute of High Pressure Physics (Poland)
June 2nd, 2014

9.7 Internal Seminars by ISOM members

2010

Dª. Gema Tabares
"High responsivity and internal gain mechanisms in Au-ZnMgO Schottky photodiodes"
January 15th, 2010

D. Zarko Gacevic
"Systematic Study of Internal Quantum Efficiency Mechanisms in III-Nitride Quantum Dots"
January 22nd, 2010

D. Roberto Cuerdo
"Source and Drain Resistances Behaviour as a Function of Temperature and Drain Current in AlGaN/GaN HEMTs"
February 26th, 2010

Dª. Sara Martín-Horcajo
"Self-heating effects in AlGan/GaN HEMTs at high temperature"
May 14th, 2010

D. Juan Gabriel Rodríguez
"The influence of the substrate roughness on the c-axis orientation of AlN/DIAMOND thin films"
May 14th, 2010

D. Manuel López
"Procesado y caracterización de nanohilos de ZnO crecidos MOCVD"
May 27th, 2010

Dª. Gao Zhan
"Synthesis and Characterization of quasi-single-crystal ZnO films on ZnO coated Silicon Substrates"
July 19th, 2010

Prof. Claudio Aroca
"Diseño de materiales magnéticos a la carta y su aplicación a dispositivos magnéticos"
November 22nd, 2010

Prof. Claudio Aroca
"Seminario sobre Seguridad en el ISOM"
December 21st, 2010

2011

Prof. Claudio Aroca
"Primeras Jornadas Científicas CAMPUS EXCELENCIA INTERNACIONAL MONCLOA. Clúster materiales para el futuro"
February 23rd, 2011

Dr. Kenji Yamamoto
"Optoelectronic devices based on oxide and arsenide compound semiconductors"
April 12th, 2011

2012

D. Juan Gabriel Rodríguez
"High precision pressure sensors based on SAW devices fabricated on diamond substrates"
May 11th, 2011

D. Miguel Romera
"Transporte Dependiente de Espín en Estructuras de Magnetorresistencia Gigante con Capas Delgadas de Gadolinio"
May 21st, 2011

Dª. Ana María Bengoechea
"Crecimiento, fabricación y caracterización de heteroestructuras y nanocolumnas ordenadas basadas en nitruros del grupo III para aplicaciones sensoras"
June 8th, 2011

D. Zarko Gacevic
"Constituent Blocks of III-Nitride Microcavities Grown by Molecular Beam Epitaxy"
June 4th, 2012

Prof. Enrique Calleja
"Generación de luz blanca eficiente con nanoestructuras semiconductoras"
November 19th, 2012

D. Alejandro Kurtz de Griñó
"Implementation of a Deep Level Transient Spectroscopy System"
December 14th, 2012

2013

Dr. Praveen Kumar and Professor Richard Nötzel
"Direct growth of InGaN on Si(111)"
April 26th, 2013

D. Paul Eduardo David Soto
"Near-infrared InN quantum dots on high-In composition InGaN"
May 10th, 2013

Dr. Naveed ul Hassan Alvi
"InN/InGaN Quantum Dots: A Surprise for Highly Sensitive and Fast Potentiometric Biosensors"
May 24th, 2013

D. Pavel Aseev
"InGaN semiconductor for novel solar cell applications"
May 30th, 2013

D. Alejandro Kurtz de Griñó
"Doping difficulties in wide-bandgap oxides for optoelectronics"
May 30th, 2013

D. Antonio David Utrilla
"GaAsSbN capped InAs QDs: A new nanostructure-based approach for telecom wavelengths"
May 30th, 2013

D. Juan Gabriel Rodríguez
"Ultra-High frequency thin film SAW devices"
June 4th, 2013

D. Steven Albert
"In(Ga)N/GaN nanocolumnar structures for solid state lighting"
June 7th, 2013

D. Tommaso Brazzini
"Properties and applications of high electron density structures based on InN and related compounds"
December 20th, 2013

9.8 Scientific workshops and meetings organized by ISOM members

2010

RAINBOW SECOND TRAINING WORKSHOP, 31st, August, 2010, Madrid

"Growth and properties of InN and indium containing alloys"

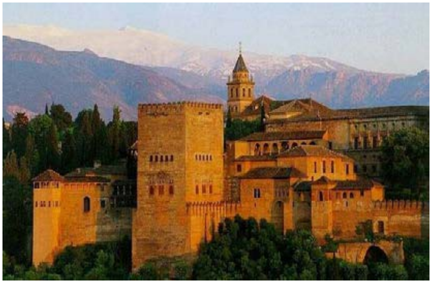
Tuesday 31st August 2010
8:30 *MBE growth of nitrides*, E. Calleja, UPM
9:30 ***XRD***
(part 1) *Principle*, M. Morales, CIMAP
(part 2) *Applications to investigation of semiconductor materials and heterostructures*, J. Domagala, IFPAN
10:30 Coffee break
10:50 *MOVPE growth of nitride materials*, M. Pristovsek, TUB
11:50 ***TEM***
(part 1) *Instrumentation and application to investigation of defects in nitrides*, P. Ruterana, CIMAP
(part 2) *Quantitative information retrieval*, S. Kret, IFPAN
12:50 Lunch break
14:30 *Growth and characterization of InN-related materials*, Y. Nanishi, Ritsumekan University, Japan
15:30 *HVPE growth of nitrides*, D. Martin, EPFL
16:30 Coffee break
17:00 *The magic of GaInN/GaN quantum wells: Optical properties and mechanism of high efficiency*, A. Hangleitler, Technische Universität Braunschweig, Germany
Wednesday 1st September 2010
8:30 *Indium segregation in InGaN and AlInN including pressure effects*, T. Suski, UNIPRESS, Poland
9:30 *EBSD and associated imaging*, C. Trager-Cowan, USTRA
10:30 Coffee break
10:50 *Positron annihilation spectroscopy*, F. Tuomisto, TKK
11:50 Round Table and conclusion
13:00 End of the Workshop / Lunch and Departure

Attendance
1. CIMAP: A. Vilalta-Clemente, G. R. Mutta, H. Lei, M. Morales, P. Ruterana
2. TUB: D. Skuridina, D. V. Dinh, P. Vogt, M. Pristovsek
3. UPM: M. A Sanchez, F. Caille, E. Cailleja, S. Albert, T. Brazzini
4. AIXTRON: O. Tuna, C. Giesen
5. UNIBO: A. Cavallini, D. Cavalcoli, B. Fraboni, A. Minj, S. Pandey
6. III-V Lab: M. A. Poisson, P. Gamara
7. FSU: L. C. de Carvalho, A. Belabbes, F. Bechstedt
8. USTRA: N. Gunasekar, S. Kraeusel, B. Hourahine, C. Trager-Cowan

2011

Workshop on Frontier Photonic and Electronic Materials and Devices

-2011 German-Japanese-Spanish Joint Workshop-
March 16-18, 2011. *Granada* (Spain)



Chairmen: Elías Muñoz, Akihiko Yoshikawa and Holger Grahn
Advisers: Kiyoshi Takahashi and Klaus Ploog

Sponsored by:
- The 162nd Committee on Wide Bandgap Semiconductor Photonic and Electronic Devices, Japan Society for the Promotion of Science (JSPS)
- Universidad Politécnica de Madrid (UPM), Institute of Optoelectronics and Microtechnology (ISOM) and Dept. of Electronic Engineering (DIE).
- Universidad de Granada (Dept. of Electronics and Computer Technology)

The workshop is based only on invited talks given by consolidated researchers in the area of "Frontier Photonic and Electronic Materials and Devices"

Topics:
1. **Frontier Photonic and Electronic Devices and Materials**
2. **Nano-structure Materials Devices**
3. **Growth and Properties of Novel Functionality Materials**
4. **Advances Characterization on Optoelectronic Materials**
5. **Spin Materials and Devices**

2012

Coupled WOCSDICE/EXMATEC 2012 conference
28th May-1st June 2012
Island of Porquerolles (France)

WOCSDICE is an annual meeting with a long standing tradition as it was established in1973. The workshop brings together internationally recognised researchers and promising young scientists and engineers to disseminate state-of-the-art research findings in the areas of compound semiconductor materials, associated devices and integrated circuits. Last WOCSDICE workshops were organized in Leuwen (2008), Malaga (2009) and Darmstadt (2010).

In 2012, WOCSDICE will be organized by CRHEA-CNRS in Porquerolles (France) from Monday, May 28, 2012 to Wednesday, May 30 2012, with a one day overlap with EXMATEC.

EXMATEC has been based on biannual meetings for 20 years. The scope of EXMATEC includes material fabrication, characterization and processing of compound semiconductors. Works on devices are also appropriate in this context. The central topics are development, improvement and application of new and advanced methods in the fabrication and evaluation of compound semiconductor materials and structures to develop understanding of the interrelationship between structural, electrical and other material properties and device characteristics, such as performance, reliability, reproducibility, lifetime, yield, etc. The conference topics apply to all compound semiconductor materials, related structures and processing. Exmatex has been previously held in Lyon, Parma, Freiburg, Cardiff, Heraklion, Budapest, Montpellier, Cadiz and Lodz (2008) and Darmstadt (2010). In 2012, EXMATEC will be organized by CRHEA-CNRS in Porquerolles (France), from Wednesday, May 30 2012 to Friday, June 1, 2012, with a one day overlap with WOCSDICE.

2012

HETECH 2012, 21st European Workshop on Heterostructure Technology.5-7 November 2012, Casa Convalescència, Barcelona (Spain)

The 21st HETECH Workshop is intended to bring together young scientists, engineers and post graduate students along with experienced researchers and industry representatives, working in the field of compound semiconductors and other heterogeneous technologies focusing on materials and devices for electronics, optoelectronics and sensing.

In the last years, special emphasis has been put on Wide Band Gap and Narrow Gap based devices. Novel materials and device concepts, such as Nanowires, Carbon based devices and Bio-chemical sensors are topics of increasing interest.

2013

UPM SUMMER COURSE: "Emerging applications of graphene"
15-16 July 2013. E.T.S.I. Telecomunicación, Universidad Politécnica. Madrid (Spain)

El lunes 15 y el martes 16 de julio se celebrará en la ETSI de Telecomunicación UPM el curso **"Emerging Applications of Graphene"**. El curso está incluido en la oferta de cursos de Verano de la Universidad Politécnica de Madrid aunque no se celebre en la sede de los mismos en La Granja de San Ildefonso.

Este seminario, dirigido por el profesor Fernando Calle, contará con la presencia de expertos en el que algunos llaman material del futuro: el grafeno. Podemos destacar, entre otros, a Tomás Palacios, egresado de la ETSIT-UPM que actualmente investiga en el MIT (Boston, USA) o Jose A. Garrido de la WSI-TU (Munich, Germany, además de otros invitados de la academia (ICMM-CSIC, ICFO, Nanogune, UPM) y la empresa (Airbus, Avanzare, Graphenea, Nokia).

Está dirigido a estudiantes de 3º y 4º de grado y de máster y doctorado de ingenierías y ciencias, así como a todos los interesados en este campo de tanto interés científico y tanto potencial industrial. Se impartirá completamente en ingles en la ETSI de Telecomunicación del 15 al 16 de julio.

Como ya empieza a ser conocido más allá del ámbito académico, el grafeno es un material emergente único, con extraordinarias propiedades y enormes perspectivas científicas e industriales en numerosos sectores de la electrónica y optoelectrónica, la energía, la salud, la aeronáutica y la defensa, la construcción, y muchos otros campos de la ingeniería de materiales. El interés científico que motivó la concesión del Premio Nobel de Física en 2010 a Geim y Novoselov (http://www.nobelprize.org/nobel_prizes/physics/laureates/2010/) pronto dio paso a muy elevadas inversiones por compañías americanas y asiáticas, como IBM y Samsung, y a la reciente concesión de un mega-proyecto europeo de 1000 M€ para los próximos diez años (http://www.graphene-flagship.eu/GF/index.php).




Creemos llegado el momento de contribuir desde la UPM a divulgar las aplicaciones potenciales del grafeno en muchos de los distintos sectores que se verán afectados por el grafeno, como son la electrónica y optoelectrónica, la energía, la salud, la aeronáutica y la defensa, entre otros campos de la ingeniería de materiales. Por ello, este Curso de Verano titulado **Emerging applications of graphene,** dirigido a estudiantes de ingeniería o ciencias en grado, máster y doctorado, tratará sobre el presente y futuro cercano del grafeno desde una perspectiva eminentemente práctica.

2013

MagSpace13. "1st International Workshop on Magnetism in Space" July 22nd-23th, 2013. Puerto de Navacerrada (Madrid, Spain). Organizado en colaboración con el INTA

22nd-23rd July 2013, Puerto de Navacerrada, Madrid (Spain)

Workshop on "Magnetism in Space"
Programme

22nd July

Morning session
Wellcome & Accommodation

- Marina Díaz (diazma@inta.es)
  - Magnetic Measurements in Missions to Mars
- Fátima Martín -Hernández (fatima@ ucm.es)
  - Low -temperature magr

phase transition

- Rolf Kilian (kilian@uni -trier.de)
  - Magnetic anomalies on the Mars: What can we learn from terrestrial analogs?

Afternoon session

- (*Skype) Mike McHenry (mm7g@andrew.cmu.edu)
  - Crystal Chemistry and Magnetic Properties of Spinel Oxides in the Fe -Ti- O Sys
- Ana Fernández (fernandezdab@inta.es)
  - Magnetic Minerals Database and Terrestrial Analogous Modelling
- Marco Maicas (maicas@fis.upm.es)
  - Micromagnetic simulation
- Whitney Schoental (whitney.schoenthal@gmail.com)
  - Switching in Ulvospinel Rich Titanomagnetites

23rd July

Morning session

- Claudio Aroca (caroca@fis.upm.es)
  - Magnetic AC susceptometers
- José Luis Mesa (mesaujl@inta.es)
  - TITANO DC Susceptometer
- Fátima Martín -Hernández (fatima@ ucm.es)
  - Low field magnetic susceptibility as a function of field strength and its

relationship with domain states in hematite natural crystals

- Laura Martín o Adriana Santiago
  - Optical and Magnetic analysis of Patagonian samples: Method and

preliminary results
lunch
Afternoon session

- Gregg Mcintosch (gregc@fis.ucm.es)
  - Magnetic properties of some martian surface analogues
  - Miguel Felipe Cerdán (miguelcmf@gmail.com)
- MOURA Magnetometer and Gradiometer

9.9 Awards and Other Activities

2011

- **D. Hosseini, S. Conesa, J.M. Rebled, S. Estradé, C. Magen, Z. Gacevic, S. Fernández Garrido, E. Calleja, F. Peiró,** *"Best Poster Award presentation, STEM-HAADF-EELS and HRTEM assessment of cubic-hexagonal transitions and In-enrichment in InAlN/GaN Bragg reflectors grown by plasma-assisted Molecular Beam Epitaxy",* Microscopy of Semiconducting Materials 2011, Cambridge, United Kingdom, 4th - 7th of April of 2011.

- **Dra. Rocío Ranchal Sánchez,** *"Young Scientist Award in recognition to her promising research career in Materials Science",* 18th International Symposium on Metastable, Amorphous and Nanostructured Materials (ISMANAM 2011), Gijón, Spain

- **Prof. Enrique Calleja, A. Bengoechea-Encabo, S. Albert, M.A. Sánchez-García, F. Barbagini, E. Luna, A. Trampert , U. Jahn , P. Lefebvre,** *"Best Paper Award was selected for the oral presentation entitled "Efficient phosphor-free, white light emission by using ordered arrays of GaN/InGaN nanocolumnar LEDs grown by Selective Area MBE",* Workshop On Frontiers in Electronics (WOFE 2011) San Juan, Puerto Rico, December 18-21, 2011.
  http://w-ofe.org/index.html

- **Sara Martín Horcajo,** *"Best Paper Award in the track of Materials and Process Technology (oral presentation) ",* 8th Spanish Conference on Electron Devices (CDE), Palma de Mallorca, Spain (2011)

2012

- **Dr. Álvaro Navarro Tobar,** "Premio Extraordinario de Doctorado (curso 2010-2011)" Universidad Politécnica de Madrid.

2013

- **Dr. Javier Martínez Rodrigo, "Premio a "Graphene Light, mejores ideas de negocio". X Competición de Creación de empresas, Actúa-UPM", Universidad Politécnica de Madrid.**

http://www.upm.es/institucional/UPM/CanalUPM/NoticiasPortada/Contenido/dda308026e1c2410VgnVCM10000009c7648aRCRD.

Graphene Light

El segundo premio de la competición se ha concedido a la propuesta para obtención de energía limpia de farolas urbanas mediante el uso de grafeno, Graphene Light, desarrollada por Javier Martínez Rodrigo, investigador del Instituto de Sistemas Optoelectrónicos y Microtecnología (ISOM) de la Universidad Politécnica de Madrid. El premio tiene una dotación de 10.000 euros.

- **Dr. Zarko Gacevic,** "Premio Extraordinario de Doctorado (curso 2011-2012)", Universidad Politécnica de Madrid.

10 FUNDING INSTITUTIONS

Our Institute has two optical mask aligners, a KarlSuss MJB3 and an MJB4 with a resolution of 500 nm.

This picture shows the MJB4 with a screen for the alignment and a chuck that allows wafers up to 4". The different processes require the use of a wide variety of photoresists (ie, 4214, SU8, PMMA).

10.1 International Companies and Public Institutions

- Sixth and Seven Framework Programme for Research and Technological Development (EU)
- Marie Curie Actions (EU)
- European Regional Development Fund (FEDER)
- European Space Agency -ESA
- European Defense Agency –EDA
- Western European Union (WEU) - WEAO Research Cell.
- European Office of Aerospace Research and Development.

10.2 National Companies and Public Institutions

- Comunidad Autónoma de Madrid
- Ministerio de Educación y Ciencia, Ministerio de Ciencia e Innovación (MICINN)
- Ministerio de Industria, Turismo y Comercio
- Ministerio de Defensa-CIDA
- Universidad Politécnica de Madrid
- Real Casa de la Moneda, Fábrica Nacional de Moneda y Timbre de España
- INDRA SISTEMAS, S.A.
- METRO MADRID S.A
- ACCIONA ENERGIA SOLAR

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