NANOSCIENCE ACTIVITIES IN THE TRAIN^2 PROJECT AND THE SUDOE REGION

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PARTNERSHIP
9 Beneficiaries
4 Associated Partners

Content

1. Introduction to the TRAIN^2 project and list of partners.

TRAIN^2 proposes the establishment of an interdisciplinary collaborative action in nanoscience and nanotechnology to unify efforts in the SUDOE area through transnational cooperation. The project focus on the optimization of scientific and technical infrastructures already existing, but not currently coordinated, to make the SUDOE region a consolidated area for research, innovation and education in nanoscience and nanotechnology. It benefits from interaction and synergies between professionals, researchers and entrepreneurs of the SUDOE area involved in the fields of nanoscience and nanotechnology

The objectives are as follows:
- To build networks of scientific and technical infrastructures to improve the shared use of the skills and the resources, and that can offer specialized services in nanotechnology to industrials.
-To address concrete research projects and fundamental challenges in nanoscience through the creation of a task force composed by transnational groups.
-To establish scientific and technical training programs for Master and PhD in nanotechnology.
-To consolidate the consortium to create a scientific network of reference that becomes the catalyst for synergies in nanoscience and nanotechnology in the SUDOE area, embracing the private sector and innovative SMEs.

For the development of the project, several groups of tasks are conducted:
-Organization and planning of all TRAIN^2 activities.
-Establishment of a network of infrastructure in micro-nanofabrication and nano characterization.
-Implementation of scientific collaboration in nanoscience in the following areas:

- Nano magnetism and spintronics,
- Molecular and low dimensional systems,
- Nano biosciences,
- Nano-catalysis,
- Micro- and Nano-devices.

-Transnational cooperation for the implementation of Master and PhD programs.
-Promotion of the development of nanotechnology in the industrial world with sustainable and specific programs (such as the promotion and support of the technology industries).
-Monitoring and evaluation of the project.

These actions will allow first strengthening the relations between the partners and the scientific and technological environment in nanoscience and nanotechnology of the SUDOE area, then root the establishment of an expertise platform open to external actors of the regional technological and economic developments

The expected benefits are:

-A significant increase in the scientific and technological transnational cooperation. This will lead to a high impact and scientific excellence in the field of nanoscience regarding other European regions.

- A greater involvement of industrials in nanotechnology-related technologies, to improve their competitiveness, transferring state-of-the-art knowledge and techniques, providing expertise and guidance for innovation and networking regional strengths towards common goals and within the frame of EU strategy (H2020,…)

- The establishment of structures of shared scientific resources, which will be extended to centers and institutions of the SUDOE area not belonging to the consortium.

- The establishment of a mode of operation of the project which can incorporate emerging centers as the Iberian Nanotechnology Laboratory (INL, Braga), the Institute of Nanotechnology IMDEA (Madrid), developments in nanotechnology of the University of Cantabria and others under development in the SUDOE area.

Project leader:

- Universidad de Zaragoza (ES-Aragón) www.unizar.es
  - INA (Aragón)
    www.unizar.es/ina/index.php

Partners:

- CIC NanoGUNE (ES-País Vasco) www.nanogune.eu/en
- Institut Catala de Nanotecnología (ICN) (ES-Cataluña) www.icn.cat/
- UniversidadPolitécnica de Valencia (ES-ComunidadValenciana)www.upv.es/
- AgenciaEstatalConsejo Superior de InvestigacionesCientíficas (ES-Comunidad de Madrid):
  - ICMA (Aragón) www.icma.unizar-csic.es/WebICMA/
  - CNM (Cataluña) www.cnm.es/
- Instituto de Engenharia de sistemas e Computadores-Microsistemas e Nanotecnologias (PT-Lisboa) www.inesc-mn.pt
- Centre National de la Recherche Scientifique CNRS-Bordeaux (FR-Aquitaine):
  - CBMN www.cbmn.u-bordeaux.fr/
  - CRPP www.crpp-bordeaux.cnrs.fr/
- Centre National de la Recherche Scientifique CNRS-Toulouse (FR-Midi-Pyrénées):
  - CEMES www.cemes.fr/
  - LAAS www.laas.fr/
  - LCC www.lcc-toulouse.fr
  - LPCNO lpcno.insa-toulouse.fr/
- Université Montpellier 2 (FR-Languedoc-Rousillon):
  - IES mitea.univ-montp2.fr/
  - LCVN www.lcvn.univ-montp2.fr/

Associated partners:

- International Iberian Nanotechnology Laboratory (PT-Norte) inl.int/
- Universidad de Cantabria (ES-Cantabria)
  www.unican.es/index.html
- Instituto de Física dos Materiais da Universidade do Porto (IFIMUP)(PT-Norte)
  http://faraday.fc.up.pt/ifimup-in

2. Description of the activities in Nanosciences within the TRAIN2 project

This workpackage was coordinated by J.M. De Teresa (ICMA-CSIC) and all the TRAIN^2 partners contributed to it. The workpackage first aimed at the identification of opportunities for collaborative projects amongst the TRAIN^2 partners, facilitated by a program for short stays to boost scientific exchanges and encourage regional collaborations and the organization of one workshop per thematic area. The identified five thematic areas, where the SUDOE region is strong, are:

-**Nanomagnetism and Spintronics**

-Molecular and other low-dimensional nano-systems

-**Nanobiosciences**

-Nanocatalysis

-**Micro- and nano-devices**

Five workshops were organized corresponding to these five thematic areas:

-Nanomagnetism and Spintronics: organized by A. Berger in San Sebastián during 22-24 February 2012

-Molecular and other low-dimensional nano-systems: organized by X. Bouju and R. Vallée in Toulouse during 19-20 June 2012

-Nanobiosciences: organized by J.P. Aimé in Bordeaux during 14-17 November 2011

-Nanocatalysis: organized by B. Chaudret in Toulouse during 20-21 December 2011

-Micro- and nano-devices: organized by S. Cardoso in Lisboa during 12-13 January 2012

Many short stays were developed amongst the different partners in order to establish links and explore opportunities for future collaborations. Many of those links have already produced a better understanding of research and technological activities, facilitating the joint contributions of partners to large EU-initiatives (Graphene Flagship as an example, but also several other projects under review (Marie-Curie networks, STREP projects,…)

Another important action within this workpackage concerned the establishment of a table with the research capabilities of the different partners. This allows the identification of the strengths of the SUDOE region in Nanosciences.

The partners provided data to fill in databases on the nano-objects which are synthesized in the different centers. Such databases have been uploaded in the project webpage. They have been made available to all partners of the consortium and beyond.

All the partners contributed to write a SWOT report describing the Strengths, Weaknesses, Opportunities and Threats for Nanoscience in the SUDOE region. This is an essential document for further development of BEYOND TRAIN^{2} activities, enforcing sustainability of the consortium and opening new horizons and priorities.

3 Opportunities for research collaborations

As shown in the following sketch, the opportunities amongst the different partners around the five thematic areas have been established.

-Nanomagnetism and Spintronics:

+ ICMA-INA-IFIMUP
+ ICMA-INA-CEMES
+ IFIMUP-INESC
+ INL-INESC
+ INA-NANOGUNE
+ ICMA-NANOGUNE
+ ICN-NANOGUNE

-Nano-biosciences:

+ INA-CRPP
+ CBMN-CEMES
+ INA-LPCNO
+ CEMES-NANOGUNE

-Micro- and Nano-devices:

+ ICMA-INA-INESC
+ ICMA-INA-CNM
+ CNM-ITQ-ABENGOA
+ LASS-CNM
+ LAAS-ITQ
+ INESC-INL
+ CNM-NANOGUNE
+ CRPP-NANOGUNE
+ CEMES-CBMN
+ CEMES-INA

-Molecular and other low-dimensional nano-systems:

+ INA-CEMES
+ INA-CNM
+ UM2_LCVN-INA

-Nano-catalysis:

+ ITQ-LPCNO
+ LPCNO-INA
+ ITQ-INA

Figure 1.Opportunities for collaboration in the TRAIN^2 SUDOE project.

From this, it can be noticed that a significant part of these opportunities orbit around the topics “Nanomagnetism and Spintronics” and “Micro- and Nano-devices”. For the present report, we have selected a few of these opportunities in order to give the flavor of the type of collaborations arising from the interaction amongst the partners.

Example 1: <u>ICMA-INA-CEMES</u>. The collaboration is focused on the imaging by Lorentz Microscopy and Electron Holography techniques of cobalt magnetic nanowires grown on silicon nitride membranes. ICMA/INA take charge of the sample growth and CEMES/INA take charge of the electron microscopy experiments. One PhD student (L. A. Rodriguez Domingez) is working on that topic under the co-direction of E. Snoeck (CEMES) and C. Magen (INA). Another collaboration concerns the structural STEM-HAADF studies of complex oxides in thin films and multilayers at the nanometer scale. This collaboration involves STEM experiments on the Cs corrected Titan low base microscope and STEM image simulations.

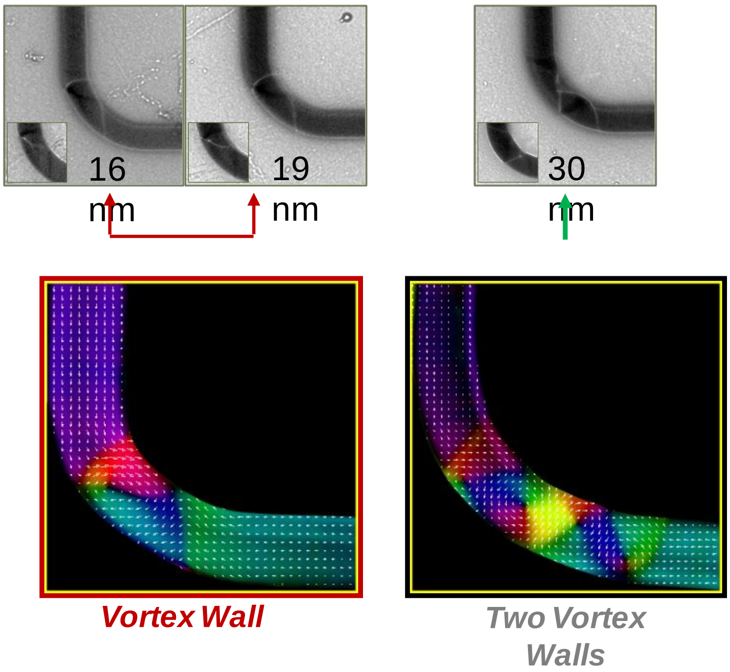
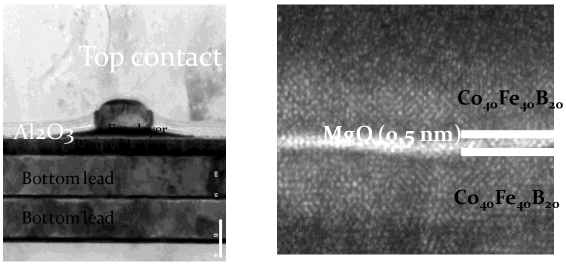


Figure 2.Domain wall configurations in cobalt nanostructures probed by Lorentz microscopy and Electron holography, studied by ICMA-INA-CEMES.

Example 2: ***<u>INESC-INL-IFIMUP-INA-ICMA.</u>*** Several collaborationsexistthat arefocused on the fabrication and investigation of magnetoresistivedevices for basic studies of spin-dependenttunnellingphenomena and spin-transferoscillators.



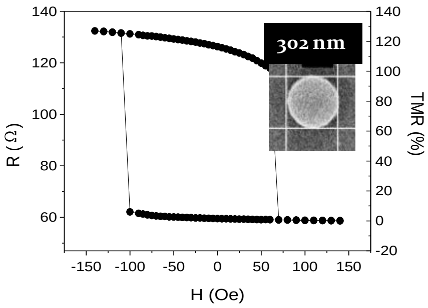


Figure 3.Magnetoresistive sensors based on low-resistance magnetic tunnel junctions with nanometric dimensions for spin transfer nano-oscillators.

Example 3: ***CNM-NANOGUNE.*** The collaboration isfocused on the use of advanced nanolithography techniques to fabricate INTERDIGITATED ELECTRODES (IDEs). These devices will be combined with microfluidic system to measure biomolecules. A PhD student from CNM is visiting nanoGUNE to fabricate optimized IDEs, combining knowledge from both parties.

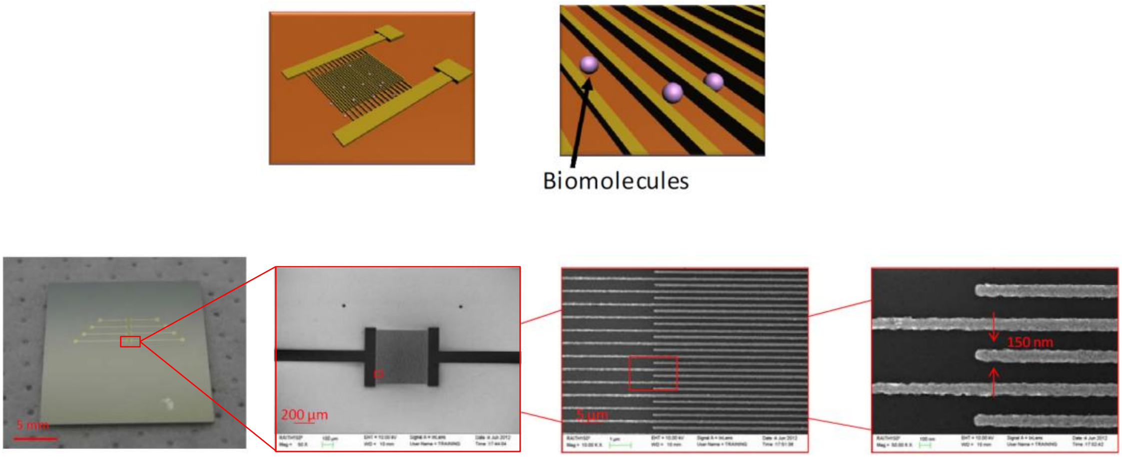


Figure 4.Interdigitatednanoelectrodes for application in label-free biosensing.

Example 4:***CEMES-INA.*** The collaboration isfocused on a hybridorganicmonolayer-metalelectrodenanodevice. The molecules have been contacted by stencil lithography in order to prevent the short circuit and studied by conductive AFM.

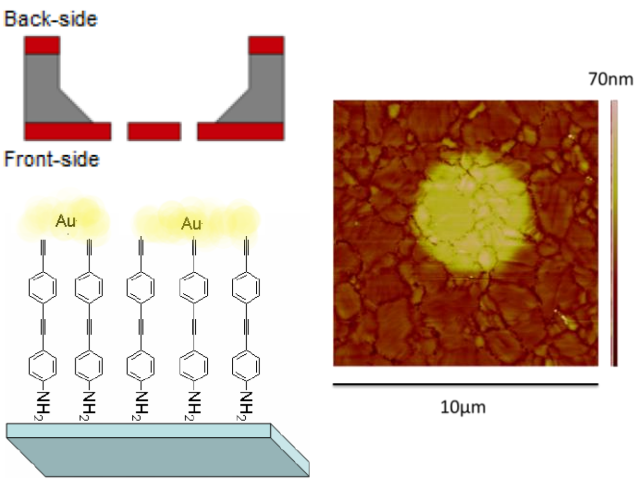


Figure 5.Interdigitatednanoelectrodes for application in label-free biosensing.

Example 5:*CEMES-NANOGUNE.*The collaboration isfocused on Nanofluidics in biological self-assemblednanochannels.An original method is proposed to measure the liquid flow in an individual Tobbaco Mosaic Virus (inner diameter = 4 nm). It is based on an AFM-based nanodispensing technique developed in CEMES, which provides a new efficient way to connect a single tube incorporated in nanodevices fabricated in NANOGUNE.

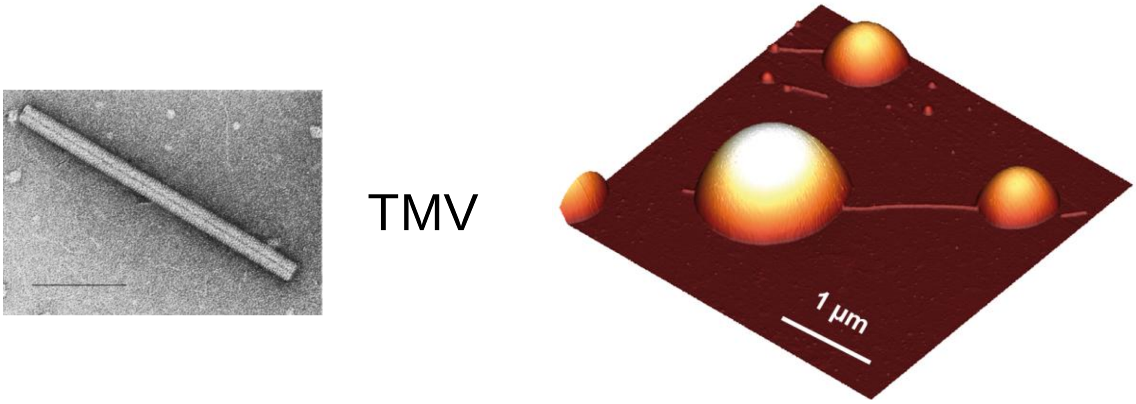


Figure 6.Left: TEM image of the Tobbaco Mosaic Virus (TVM). Right: AFM image of the virus and droplets nanodispensed for studies of nanofluidic connectivity through the central free channel of the TVM.

Example 6:*INESC-INA-ICMA.*The collaboration isfocused on magnetoresistivesensordevelopment for particledetection in biological applications. Several architectures are developedat INESC-MN, within the several collaborations witheuropean groups and sensingplatforms are builtat INA-ICMA and at INESC-MN.

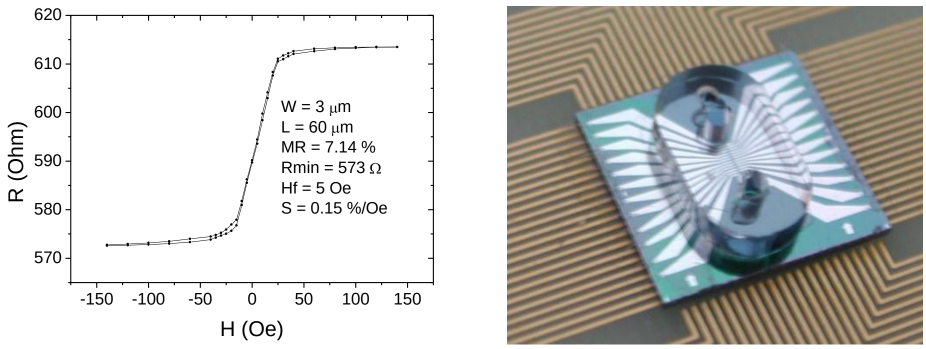


Figure 7. Left: Magneotoresistive sensor with optimized linear response for biological applications and biochips. Right: Integrated microfluidic and biochip sensor for magnetic nanoparticle dynamic counting.

4. Tables with research capabilities

In the following, five tables have been completed with the information on the existing capabilities in each research center within the field of Nanosciences. The numbers 0 to 4 indicate the expertise of each center in the corresponding topic, with the meaning: 0=no experience; 1=little expertise; 2=medium expertise; 3=high expertise; 4=very high expertise. The total number, obtained adding the numbers of all the partners, gives an idea of the potentiality of the overall capacity of the TRAIN^{2}partners in the topic.

Nanoscience expertise Table

NanoMagnetism and Spintronics

Topic	CEMES	CIC nanoGUNE	CNM	ICMA	UNIZAR/INA	ICN	UM2-IES-L2C	IFIMUP	INESC	INL	LAAS	UNICAN	TOTAL
Materials growth and device fabrication	2	3		3	3	4	0	1	4	3		2	25
Magnetic thin films and multilayers	3	4		3	4	4	0	1	4	3		2	28
Magnetic liquids and ferrofluids	0	1		2	1		0	0	0	0		3	7
Magnetic nanoparticles	3	2		3	3	4	0	2	0	3		3	23
Magnetic nanostructures	3	3		4	3	4	0	2	3	3		3	28
Magnetic hybrid materials (…superconductor/FM, etc)	2	2		2	3	3	0	1	3	3		2	21
Magnetic oxides and multiferroic materials	3	2		3	3	3	0	2	2	0		2	20
Magnetometry	3	4		3	3	4	0	3	3	3		3	29
Magnetic microscopies	4	3		2	4	2	0	0	2	2		1	20
Magneto-optics	2	4		1	0	3	3	2	0	0		2	17
Neutron or x-ray based measurement techniques	0			3	3	3	0	2	2	2		4	19
High frequency measurement techniques	2			1	0	3	1	2	3	2		0	14
Theory and simulations	3	2		2	1	1	0	1	2	3		0	15
Fundamental magnetic properties (exchange, anisotropy, magneto-elastic, etc.)	2	4		3	3	3	3	2	2	2		3	27
Micromagnetic structures and magnetization reversal	2	4		2	2	3	0	1	2	2		0	18
Dynamic magnetic phenomena and properties	3	3		1	1	3	3	2	2	1		4	23
Magnetic phase transitions	1	4		4	3	2	1	2	0	0		3	20
Magnetic propeties of non-ferromagnets or non-conventional ferromagnets	1	2		3	2	3	2	1	0	0		3	17
Magnetocaloric and other thermal effects	0	3		4	3	2	0	3	0	0		3	18
Spin transport properties	2	4		3	3	4	0	3	3	2		2	26
Magneto-transport properties and tunnel junctions	3	3		4	3	3	2	3	4	3		1	29
Magnetic sensors	2			2	3	1	1	2	4	3		1	19
Bio applications and magnetic hyperthermia	0	2		3	4		0	1	4	3		1	18
Novel devices and applications	1	2		3	3	4	0	1	3	3		1	21

Nanoscience expertise Table

Molecular and other low-dimensional nanosystems

Topic	CBMN	CEMES	CIC nanoGUNE	CNM	ICMA-INA	ICN	IFIMUP	INESC	INL	LAAS	LCC	LCVN-UM2	UPV-ITQ	CRPP	UNICAN	TOTAL
Objects																
Single molecule		4	2		2	1					0	0	0		0	9
Self-assembled monolayer		3	3		2	2					0	0	1		0	11
Carbon nanotube		2	2		2						0	4	4		2	16
Graphene		3	3		2						0	3	4		0	15
Molecular layers		2	4		1	2					1	1	1		0	12
Inorganic material		2	4		1	3					3	0	4		3	20
CVD synthesis		0	1		1						0	3	2		0	7
Colloids		3	2		2	3					3	0	2		3	18
Others (indicate) nanomembranes						4						0			0	4
Experiments and characterization tools																
Chemical synthesis		4	3		2	3					4	0	4		2	22
UHV-STM (indicate: RT, LT, SP...)		4			2						0	0	1		0	7
UHV-AFM (indicate: RT, LT, AM, FM...)		4			2						0	0	1		0	7
Electron microscopy		4	3		3	2					1	1	2		3	19
Electrochemical methods		2	3		1	3					0	1	3		0	13
Diffraction techniques		3	2		3	3					1	2	3		3	20
KPFM		3	1		1						0	0	0		0	5
Optical characterization		1	3		1	4					1	4	3		3	20
Theory, calculations and simulations		4	4		3	2					0	1	3		2	19
Others (indicate) INELASTIC LIGHT SCATTERING						4						0			0	4
Studied properties																
Conductance properties		3	3		3	3					0	3	1		2	18
Molecule/surface interactions		4	2		3	2					3	1	3		0	18
Magnetic properties		3	3		3						2	1	1		2	15
Electric properties		3	3		3	3					1	3	1		2	19
Manipulation of single objects		4	0		2						0	1	3		0	10
Mechanical properties		3	0		0	4					0	1	0		0	8
Self-assembly		3	3		2	4					1	1	2		0	16
Growth		0	3		3	3					2	3	2		0	16
Plasmonics		4	3		0						1	0	1		0	9
Others (indicate) Plasmonics theory					4							0			0	4
Others (indicate) Ionic Transport						4										
Other: thermal properties						4										

Nanoscience expertise Table

NanoBioScience-BioTechnologies

Topic	CEMES	CIC nanoGUNE	CNM	ICMA-CSIC	INA	ICN	UM2-IES	IFIMUP	INESC	INL	LAAS	CBMN	CRPP	BFP-INRA	UNICAN	TOTAL
Materials and systems																
Engineering proteins and Virus	2	3	0	0	0				0	2		4	3	3	0	17
Engineering Peptides	0	2	0	0	0				0	2				1	0	5
DNA technology	0		0	0	1	4			0	2		2			1	10
Phage and Cell display	1		0	0	0				0	2				3	2	8
SELEX_Aptamers	0		0	0	0				0	1					0	1
Membrane systems	0		0	0	0				0	1		3			0	4
Photosynthetic systems	0		0	0	0				0	1					0	1
Hybrid systems with biomaterial, organic-inorganic.	3	4	0	2	3	4			0	3			2		0	21
Hybrid systems with biomaterial (amphyphil, polymer-block copolymer)	1	2	0	0	1				0	2		3			0	9
Instrumentation and Imaging techniques																
Optical techniques and imaging, STED, Palm, TIRF, FRET, Confocal micros.	1		1	0	1	2			0	3		3		2	2	15
AFM	3	3	2	2	1				1	2		4	3		1	22
force measurements (optical, magnetic tweezers, vesicles)	0		0	0	0				2	2			1		1	6
Resonance plasmon-SPR	0		0	0	1	4			0	3					0	8
Neutron or x-ray based measurement techniques	0	1	0	3	0				0	2		3			2	11
Quartz microbalance and SAW	0		2	0	1				0	2		2			0	7
TEM-HREM	2	3	0	3	1	3			0	3		3			3	21
Electrochemistry	1	2	3	0	0	4			0	2			2		0	14
Theory and simulations	0	1	1	0	0				0	0		3			0	5
Domain of applications																
Biosensors	0	2	2	2	2	4			3	4		2	2	1	1	25
oncology	0		0	0	2	3			2	1			1		3	12
imaging in vivo	0		1	1	2				0	2		2		3	3	14
nano vectorization	0	2	0	3	3	3			0	1		2	2		0	16
Synthetic Biology	0	3	0	0	1	1			0	0					0	5

Nanoscience expertise Table

Nano-catalysis

Topic	CNRS LCC	CNRS LPCNO	CSIC-CNM	UP	UPV-ITQ	ICN	CSIC-ICMA	CIC nanoGune	INA	CEMES	CNRS CRPP	TOTAL
Nanocatalyst Synthesis												
Fe					1							1
Fe oxides				3	1	3						7
Ferrites				3	1							4
Co					1	3						4
Co oxides, Ni oxides				3	1	3						7
Pd, Pt					2	3						5
Ru,Rh					1							1
Au					4	3						7
Ag					2	3						5
Other oxides : CuO, ZnO, NiO, TiO_2					2	3						5
Carbon materials, graphene					4							4
Nanocatalyst Characterization												
NMR					2							2
AFM					2							2
TEM-HREM				3	2	3						8
XPS				3	2							5
XRD				3	2	3						8
WAXS					1							1
Theory and simulations					3							3
Catalytic Reactions												
Hydrogenation					3							3
Oxidation				3	4	3						10
C-C coupling					3							3
photocatalysis				2	4							6
Fischer-Tropsch					2							2
others												0
Nanocatalyst Synthesis												
Other oxides : perovskite oxides SrFeO3, La2NiO4, BSCF						4						4
Nanocatalyst Characterization												
AFM related ESM technique					2	3						5

UE/EU - FEDER/ERDF

Nanoscience expertise Table

Micro- and Nano-devices

Topic	UNIZAR	CNRS-Bordeaux	CRPP	CIC-NanoGUNE	UM2-IES+L2C	CSIC-ICMA	ICN	INESC-MN	UPV-ITQ	CNRS-MIdI-Pyrenees (CEMES)	CSIC-CNM	INL	UNICAN	TOTAL
PECVD/CVD deposition		1	1	2	2	2	1	2	1	3				15
Sputtering depositon		1	1	4	3	3	3	3	1	3				22
electron beam induced deposition		0	0	3	2	4	4	0	0	3				16
Ion beam deposition		0	0	3	1	4		4	0	0				12
Microlithography		0	0	3	2	3	3	3	1	3				18
e-beam nanolithography		0	0	3	1	3	4	3	0	2				16
Focused-Ion beam nanofabrication		0	0	3	0	2	3	0	0	1				9
Nano and Micromachining		0	0	3	1	2	1	1	0	3				11
Growing of nanostructures by electron / ion beams		0	0	3	0	3	4	0	0	0				10
Colloidal photonic crystals		3	3		0	0	4	0	2	1				13
Fabrication of nanofibers using electrospinning		0	0	3	0	0		0	1	0				4
Magnetic nanostructures		1	1	4	3	3	4	3	1	0				20
colloidal nanostructures		3	3		3	2	4	0	2	0				17
micro-/mesoporous materials		3	3	2	0	1	3	0	4	1				17
Photonic cristals		3	3		2	0	4	0	2	3				17
Graphene		2	2	3	3	2	4	0	4	1				21
Magnetic thin films and multilayers		1	1	4	3	3	4	3	1	2				22
Superconductors		0	0	2	0	2	4	0	0	0				8
Spin valves/GMR materials		0	0	3	3	3	3	3	0	1				16
Magnetic tunnel junctions		0	0	3	3	3	3	3	0	0				15
pyroelectric materials		0	0		3	0		0	0	0				3
Micro/Nanowires		0	0		3	3	4	0	0	3				13
Paper-based devices		0	0		1	1	3	0	0	1				6
														0
stretchable substrates		2	2	3	0	0		1	0	1				9
Sb-alloys, semiconductor nanostructures		0	0		4	1	3	0	0	0				8
AFM characterization		3	3	3	3	3	4	1	1	3				24
SEM characterization		2	2	4	3	3	4	2	1	3				24
TEM characterization		2	2	4	0	3	3	0	2	0				16
scanning near-field optical microscopy		0	0	4	3	0	3	0	0					10
FTIR microspectrometer		1	1	2	2	1	3	0	1	2				13
Low T transport measurements		1	1	4	3	3	4	1	0	0				17
														0
High frequency measurement techniques		0	0		3	1	3	2	1	3				13
Microcantilevels		0	0		2	1	4	3	0	3				13
Micro and Nanofabrication of sensors on CMOS		0	0		0	0	3	2	0	2				7
Infrared antenna and transmission lines		0	0	4	2	0		0	0	0				6
photonic devices (lasers and photodetectors)		0	0		3	0		0	1	3				7
Nanohall probes		0	0		2	2		0	0	0				4
Magnetic sensors		0	0	3	3	2	2	4	1	0				15
Sensors for biomolecular recognition		2	2	3	1	2	4	4	1	3				22
Sensor Integration with microfluidics		1	1	2	2	2	4	4	0	3				19
MicroSQUIDS		3	3		2	2		0	0	0				10
Magnetic hyperthermia		0	0	2	1	3		0	0	0				6
Bio-sensors		1	1	2	1	3	4	3	1	3				19
Biomedical applications		2	2	3	2	3	4	3	1	3				23
Gas sensors		2	2	1	3	1	1	1	1	2				14
lithium-ion batteries		0	0	1	1	0		0	2	0				4

BioMEMS		0	0		0	0	3	3	0	4				10
accelerometers		0	0		3	0		1	0	1				5
microactuators		1	1		2	0		1	0	3				8
micro energy harvesting devices		1	1	2	1	0	4	1	0	2				12
Energy microsources/Micro capacitors/Microconvertors		0	0	2	1	0	3	0	0	4				10
ChemFETs		0	0		0	0		0	0	3				3
implantable micro-electrodes		2	2		0	0		2	0	0				6
Lab-on-chip		0	0	3	1	0	4	3	0	3				14
RF devices		0	0	1	3	0	3	1	0	4				12
cell counting/separation, DNA manipulation		0	0		1	0		3	0	3				7
optofluidic devices		0	0		1	0	2	1	0	1				5
Devices for high power electronics		0	0		3	0		3	0	4				10

Additional lines:

Pulsed Laser Deposition							4							4
Ionic conducting Materials							4							4
High T transport properties							4							4
Solid oxide fuel cells							4							4

5 SWOT report

In the following, we include a SWOT (**S**trenghs-**W**eaknesses-**O**pportunities-**T**hreats) report analyzing the current state in the field of Nanosciencesinside the SUDOE region. This report aims to provide valuable information on how the SUDOE researchers perceive the present situation of Nanosciences inside the SUDOE region. This can be a useful perspective for other researchers, for companies in this field and for politicians needing to take decisions affecting Nanosciences.

We first describe the global conclusions drawn from the individual SWOT analysis of the five main thematic areas of the TRAIN^2 project. Afterwards, we include the individual analysis of each of the five topics.

SUMMARY OF THE SWOT REPORT:

STRENGTHS:

-In the SUDOE region good and modern scientific infrastructure for Nanosciences is available. Over the recent years, significant investment efforts have been developed in Spain, France and Portugal, leaving the SUDOE region in a very strategic position to be competitive at the international level in certain topics of Nanoscience and in the development of nanotechnologies (characterization, risk evaluation, manufacturing)

-The research groups have developed valuable international collaborations, these connections being very important for the internationalization of the activity in Nanosciences.

-It is also remarkable that good multi- and inter-disciplinary research of real depth has been developed in the last years, which is important as scientific breakthroughs occur frequently in such an environment.

-Recently, several spin-off companies in the field of Nanosciences have been set up from the consortium, evidencing its close relation to the private sector, and enhancing the opportunities for transfer of knowledge to industry.

-Last, but not least, researchers in the SUDOE region have similar visions of Science and Technology, with many common cultural backgrounds and similar world views, facilitating efficient team work.

WEAKNESSES:

-A general problem in the South of Europe is that the transfer of knowledge to industry is lower than desired; this holds true for Nanosciences as well.

-One additional weakness is that the maintenance and renewal of advanced infrastructure in Nanoscience is expensive and needs continuous financial support.

-All the partners also stressed the fact that the increase of the bureaucratic work is forcing researchers to spend time on urgent bureaucratic affaires, impeding the maximum use of time for research and transfer of knowledge.

-On the other hand, the existing human and infrastructureresources in Nanosciences could be better optimized in the SUDOE region if strong coordination actions, such as the current TRAIN^2 project, persist and extend in time.

OPPORTUNITIES:

-If poles of excellence were created, the centers working in Nanoscience in the SUDOE region are in a goodposition to lead research of excellence in multi- and inter-disciplinary topics.

-Globally, there is an increasing market demand for nanotechnology products, with about 3000 nanotechnology-based products nowadays.

-All studies mention that Nanotechnology is a key future translational technology in energy and environmental areas, which are very important nowadays at the European level. In that context, one mentions that Nanotechnology is one of the Key enabling Technology (KET) which are setting the foundations forEU-funding policies within the research and Innovation H2020 program. Similarly, the RIS3 platform offers the definition and positioning of Nanotechnology as one of the strengths of SUDOE in the context of Smart Specialization.

-With respect to the upcoming 8th Framework Program, particularly in relation to specific calls in Nanoscience or large-scale projects related to ESFRI or “synergy” projects, the SUDOE region is already well organized and coordinated thanks to the present TRAIN^2 project.

THREATS:

-Politicians are tempted to discontinue investment in new research infrastructure, which would render obsolete the currently existing infrastructure in Nanoscience within the SUDOE regionin about 10 years.

-Within the current economic crisis in the South of Europe, it can be possible to see lack of funds to maintain the existing infrastructure, which would imply under-utilization of the existing resources in Nanoscience in the SUDOE region.

-The foreseeable lack of grants and positions for new young researchers in the South of Europe can produce brain drain from the SUDOE region towards other European regions.

-Without further stimulus actions by the national and regional governments, one can expect the rather limited transfer of knowledge to industry to continue.

-If initiatives such as the present TRAIN^2 project are not supported in near future, the existing links in the SUDOE region can be eventually broken.

SWOT REPORT ON <u>NANOMAGNETISM AND SPINTRONICS</u> IN THE SUDOE REGION:

Strengths / *Nanomagnetism and Spintronics:*

The SUDOE region has a strong international position in the field of nano-magnetism and spintronics research and in many fields of modern research and technology, it is at the very forefront of scientific activities in this subject. Also, the scientific infrastructure is in major parts of the available equipment portfolio truly state-of-the-art. For instance, several of the recently established or extended nano-science and –technology centers, such as the INL in Braga, host under the same roof sets of tools, which are not usually concentrated in a single site, and are thus truly competitive on the European and world-wide scale. Correspondingly, the SUDOE region is currently internationally recognized as a strong region in nano-magnetism and spintronics. This stems also from the intense past activities in the field of magnetism in combination with the more recent setup of new infrastructures for nanotechnology and the arrival of new researchers with expertise in this very field of science and technology. Also, very good connections exist with many of the world-leading groups in this research area both in Europe, such as the one of Prof. Albert Fertin THALES/CNRS at Paris (Nobel Prize in this topic), for instance and all over the world .

During the past decade, advanced and unique progress in nano-magnetism and spintronics research has been made using the fairly strong recent infrastructure investment in SUDOE institutions in areas of electron microscopy, focused-ion beam and electron-beam lithography based nano-fabrication, as well as thin film growth. This is clearly bearing fruit in that the related scientific activities have moved to the very forefront of state-of-the-art research in this field. Some groups in the SUDOE region have also used their expertise in nano-magnetism in order to apply magnetic nanoparticles in nano-biosciences, including the setup of new spin-off companies. Also, there are relevant efforts towards the commercialization of magnetic nano-sensors, generally based on magnetoresistive effects. One of their main applications is in the field of biosensors, where the SUDOE area can be competitive. Overall, the SUDOE scientific community excels at branching out its scientific activities into new application areas and there are many activities ongoing that aim to utilize physical effects, fabrication and characterization capabilities of nano-magnetism and, to a slightly lesser degree, spintronics for new applications, especially in the fields of medicine and bio-technology.

Also, the SUDOE region has a very strong position, if not an outright worldwide leadership position, in the fields of magneto-optics and magneto-plasmonics. Other areas of internationally recognized strength are thin-film and multilayer fabrication, magnetic oxides, multiferroics, hybrid superconductor-ferromagnet structures, organic magneto-electronics, the physics of magnetization reversal and the theory of ultrafast magnetic switching. Also, there are extensive activities on soft-magnetic materials in the SUDOE region.

Weaknesses / *Nanomagnetism and Spintronics:*

As far as the scientific breath of research activities in the fields of nano-magnetism and spintronics are concerned, there are only a few areas, in which the SUDOE region does not show the level of activity that it could, given its overall size and relevance. These less represented fields include: Spin-Torque phenomena, fast magnetization dynamics, and theory work in the field of electronic band structure and magneto-transport.

There are certain modern infrastructures and techniques that are not available in the SUDOE region, such as for instance SEMPA or Spin-STM, which are laboratory-based high-end instrument developments. However, there are so few of these instruments within Europe and even worldwide, that their absence in the SUDOE region represents rather the norm for most regions than the exception. Also, the lack of large-scale facilities is a limitation, not so much because such facilities are not easily accessible for researchers from the SUDOE region, but more so because such centers are very easily recognized internationally and lead to the influx of foreign expertise that can enhance the local or regional scientific community. The ALBA synchrotron in Barcelona might change this situation.

A rather common weakness that also affects the SUDOE region is the lack of ties to more traditional industrial applications of magnetism and spintronics, such as information technology, which reflects the fact that major corporate technology development centers and manufacturing facilities in this industrial sector do not exist in the SUDOE region. Overall, Europe is rather weak in this regard with only few regions being an exception, such as the Grenoble (Crocus) or Belfast (Seagate) regions, for instance.

Opportunities / *Nanomagnetism and Spintronics:*

The fact that the SUDOE region recently succeeded in branching out its scientific activities to new application areas of nano-magnetism and spintronics presents a great opportunity to move from being part of the forefront of the scientific community into a true European and worldwide leadership position. This is especially true for the many activities ongoing that aim to utilize physical effects, fabrication and characterization capabilities of nano-magnetism and spintronics for new applications in the fields of medicine and bio-technology.

One example of such opportunities is the nano-scale fabrication of magnetic and spintronic materials and devices by means of novel and so far underused technologies such as focused ion-beam and electron beam induced deposition technologies. Here, capabilities are just emerging world-wide and given its infrastructure resources and research talent, the SUDOE area has a clear opportunity to be one of the world-wide leading geographic regions defining and driving progress in this field. Hereby, the excellent relations to lead European manufacturers are a crucial component as well, even though these companies are not located themselves in the SUDOE region.

Another big opportunity is the synthesis of tailored magnetic nanoparticles, where the SUDOE area is very strong. Also, the area of design, fabrication and commercialization of magnetic biosensors has great opportunities for the SUDOE region, an application field that is mainly based on magneto-resistive effects, as well as far-reaching novel lab-on-a-chip devices that utilize nano-magnetism and spintronics as core operating technology for bio-medical applications in separation, aggregation and detection. Furthermore, the combination of both, i.e. sensor and magnetic nano-particle technology, can lead to the creation of multifunctional systems with high added value and innovation potential.

Several SUDOE partners are involved in the GrapheneFlagshipinititative (www.graphene-flagship.eu) which aims at transforming groundbreaking research in Graphene and two-dimensional materials into economic value. Spintronics is one of the important research direction, and one SUDOE patner acts as Deputy of the corresponding EU-consortium. This could offer a strong positioning and leadership of SUDOE region in this field

Threats / *Nanomagnetism and Spintronics:*

A general threat for Science in the SUDOE area (especially in Portugal and Spain) is the decrease of funding observed during the last three years. The state-of-the-art infrastructures for nano-magnetism and spintronics that have been installed during the last ten years in the SUDOE area need recurrent support for maintenance and running costs, which becomes more and more difficult to get. If this situation continues for an even longer time, it will destroy most of the initiatives set up during the last decade. Also, this lack of funding for Science and Technology is not observed in the north of Europe, which can open a serious gap between the SUDOE area and other regions in

Europe. In addition, it is absolutely paramount to have an excellent and motivated workforce to achieve worldwide leadership, even if state-of-the-art scientific infrastructure is available. In particular, it takes the best early- to mid-career scientists (recent Ph.D. graduates to young staff scientists) to achieve leadership, because it is exactly this personnel segment that is the key contributor to leading-edge science and technology. However, this is also the most vulnerable segment of the scientific workforce, due to time-limited contracts and fellowship programs. So, to generate the full benefit of the recent infrastructure investment, it would be important to widen the opportunities and improve the work conditions of this group. The clear problem is, however, that in the near future the public financial situations will lead exactly to the opposite. This is a very substantial threat to the competitive position of the SUDOE region, not only but also in the fields of nano-magnetism and spintronics, and might lead to the severe under-utilization of the recent infrastructure investment, especially in terms of the quality of work and science being conducted.

One additional point of concern is that politicians managing science could be tempted to decrease funding homogeneously across all areas of research, with the final result that the SUDOE region will not be at the forefront in any scientific area and could not compete at the international level. Another threat is the lack of programs to promote joint scientific and industrial activities within the SUDOE area beyond the present SUDOE program, except for the small CTP program.

It is also a matter of concern that many of the leading researchers in the nano-magnetism and spintronics topics that were recently attracted to the SUDOE area will leave if the SUDOE region is no longer an attractive area for research. Hereby, one has to take into consideration the long time-scale with which regions build a reputation for research excellence. While the SUDOE region is internationally and widely recognized for its high standard of living, culture and tradition, it is in comparison to other region of Europe not equally noticed for its scientific and technological prowess, despite the fact that individual research groups and centers are well respected.

Another threat in this difficult financial climate is that in the SUDOE region, an appropriate environment must be created to ensure the protection of intellectual property and foster the creation of spin-off companies, which historically is not a strength of this region.

SWOT REPORT ON MOLECULAR AND OTHER LOW-DIMENSIONAL NANO-SYSTEMS IN THE SUDOE REGION:

Brief introduction to the topic

One may tackle the topic related to molecular and other low-dimensional nano-systems along three directions. First, the synthesis of nano-objects with organic or inorganic molecules may be discussed. This includes also the growth of carbon nanotubes, as well as graphene, and of nano-particles. Second, the classification may be organized around the characterization techniques, including local-probe based methods, microscopy, spectroscopy, electro-chemistry… Finally, one can discuss the goals of the studied topics, that is to say the different properties that are targeted.

The title of the topic encompasses the synthesis of organic molecules for single molecules studies. These molecules may have functionalities such as mechanical or electronic functions to mimic either a molecule-machine either a basic electronics device. Moreover, other types of molecules are used for self-assembled monolayer on a surface or self-assembled three-dimensional nano-objects. From the inorganic side, the synthesis of nano-particules is also addressed. One has to mention carbon nanotubes and graphene synthesis, as well as CVD synthesis.

Among the characterization techniques, scanning tunneling microscopy and atomic force microscopy, including Kelvin probe microscopy, are well spread out around the SUDOE area. Additionally, according to the system under study and depending on the followed purposes, microscopy and physical-chemistry methods such as electron or optical microscopy, electro-chemistry, diffraction techniques or optical characterization. To complete experimental results, theory, calculations and simulations expertises are key points to obtain information on the properties of the nano-objects.

Specific properties are explored such as conductance of single molecules or more generally electronic properties of nano-objects. In the same manner, electric, magnetic, mechanical functions are tackled. Moreover, due the great sensitivity of local-probe techniques coupled to theoretical calculations, molecule/surface interaction is a wide field of interest for research groups. In this context, controlled molecule manipulation is able to provide valuable information for mechanics but also for self-assembly. One may notice a growing field that is the plasmonics of single nanostructures or assembly of colloidal particles.

Strengths / *Molecular and other low-dimensional nano-systems:*

The SUDOE area holds a diversity of centers and infrastructures with state-of-the art equipments for nanosciences and nanotechnology. In addition, there is an interesting mix of newly created centers and consolidated centers that, in conjunction, have an enormous potential for addressing new challenges in nanotechnology. There is also a growing number of researchers and nano-related students that guarantees a proper use of these facilities.

There are highly dedicated scientists, sufficient infrastructure and equipment, with open access to information.There are leading groups with international recognition gathering experts in nanostructures and organometallic chemistry, and switchable molecular materials.We can detectinternational relevant groups on: i) Functionalized molecular systems comprising a large spectrum from single molecule machines to self-assembly and nanoparticules, ranging from metallic nanoparticles to carbon nanotubes and graphene; ii) non-contact AFM and low-temperature STM.

There exist state-of-the art research facilities for the fabrication and characterization of molecular and other low-dimensional nano-systems. Researchers working on this field at our institution are highly trained and have many years of experience in low-dimensional nanosystems. Also experts working on different types of compounds (organic, inorganic, biomaterials) are actively working in our center. One can notice also numerous international collaborations with prestigious institutions.

There are innovative groups able to design functionalized molecular systems comprising a large spectrum from single molecule machines to self-assembly. There are up-to-date equipments for the study of molecular systems on surfaces especially noncontact AFM (frequency-modulation AFM, FM-AFM), in ultra-high vacuum, in low temperature or room temperature environment. On the other hand, there is an activity on carbon nanotubes (manipulation and characterization) and on graphene-based nanoelectronics. Finally, an original ultra-high vacuum (UHV) factory equipment has been especially designed for the elaboration under UHV of the five levels of interconnection necessary to exchange information with a single molecule or nanoobject.

There exists numerical studies that are performed on self-assembled molecules on oxide surfaces.With the objective to study individual isolated carbon nanostructures in order to address their intrinsic properties, an overall approach involves the combined use of powerful characterization tools with diagnostics of the nanostructure physical properties (micro-Raman and optical spectroscopy, scanning probe microscopy, electrical and opto-electrical transport measurements).

For the Low Temperature-STM (LT-STM), one has to mention four groups (Barcelona, Zaragoza, San Sebastian, Toulouse) that are well recognized around world and having an activity which is in the race in this field of research. For FM-AFM that is a European « specialty », leading groups using a qPlus system exist in the SUDOE area.

This is a multidisciplinary research line whose development nourishes from knowledge and new ideas from different fields (physics, chemistry, materials science, biology, biochemistry, pharmacy, medicine, etc.) which makes it especially innovative.

There are many international high-quality collaborations in this topic.

There is a continuous effort of instrumental development (at INA with a spin-polarized LT-STM, at CEMES with a LT-four probe and UHV factory, and soon at NanoGune, San Sebastian). Beyond the already mentioned excellence centers, one may notice the creation of PicoLab (CEMES, Toulouse), the Flagship project (with leading people at ICN, Barcelona) and the ERC Comosyel (Cemes, Toulouse) on graphene.

Weaknesses / *Molecular and other low-dimensional nano-systems:*

There is a lack of identified industries in the SUDOE area that could take direct benefit of the research activities and define research lines of industrial applications.

One can detectconsiderable and increasing bureaucracy with an incredible large number of researchers hours dedicated to reporting and managing. Researchers are facing extremely complicate and lengthy reporting procedures with a lack of flexibility. For each researcher working in new Science there must be several auditors at different levels.

There is a decreasing funding to research projects and fellowships for the training of new researchers from European and National governments due to the financial crisis. One may notice difficulties to attract the interest of the local industry and lack of identified companies in the SUDOE area in connection to nanotechnology.

One may point out a lack of coordinated actions due to the individual competition in the world race. It is often easier to work with foreign groups than with national or regional teams.

Regarding the need of interpretation of the numerous experimental results, there is a limited number of groups to calculate molecular conformations on surfaces and local probe images. Even though there already exist people developing methodology and numerical codes (Siesta) that are important for the community, a community of users is rather missing.

Adecreasing funding to research projects and fellowships for the training of new researchers from European and National governments due to the financial crisis is noticed.

Difficulties are encountered to attract the interest of the local industry.

Opportunities/ *Molecular and other low-dimensional nano-systems:*

There are big opportunities for addressing scientific and technological challenges through collaborations and networking between the different entities involved in nanosciences and nanotechnology in the SUDOE area. There are big opportunities for collaboration with high-quality researchers and in well-equipped centers.

There is a growing interest for the development of very sensitive apparatus, not only in nc-AFM but also in the STM expertise (for instance, the vey low temperature environment with magnetic field for the detection of spin related phenomena at the single atom/molecule level).

Experts working on different types of compounds (organic, inorganic, biomaterials) are actively working within international collaborations with prestigious institutions.

There is potential in terms of researchers and infrastructure to create a cluster competitive at the European and World level, on carbon nanotube studies, single and self-assembled molecular systems.

There exists opportunities to contact companies that could be interested in our research.

Threats/ *Molecular and other low-dimensional nano-systems:*

In view of the present economic situation, there is a big threat of a decrease of available funding for maintenance and renewal of equipment and infrastructure, and human resources for scientist and technicians. These would now allow the SUDOE area to be in a competitive level in comparison with other areas in Europe.

Many peoplefear anincrease in bureaucracy and audits, and in the same time lower funding.Regional and local policy makers of the SUDOE area are not enough concerned with the problem of researchers in nanosciences and nanotechnology are facing.

SWOT REPORT ON <u>NANO-BIOSCIENCES</u> IN THE SUDOE REGION:

Strengths / *Nano-biosciences:*

A large diversity of institutions (universities, research laboratories) which are in general well equipped with human resources and facilities in Nano+Bio.

Spin-off companies in this topic have emerged in the SUDOE region during last years.

We perceive a common culture and world view, facilitating communications.

Weakness/ *Nano-biosciences:*

There is poor knowledge and interaction between laboratories.

One finds a low number of biotech firms and limited interaction with research laboratories.

Opportunities/ *Nano-biosciences:*

The interdisciplinary research in new topics requires new outlook and possibility of forming poles of excellence.

Biotech applications do not require immense funds/facilities for research and development.

An increase in the regular interaction between groups, supply funding for conferences and research projects (seed money very important for exploratory work) is possible.

Threats/ *Nano-biosciences:*

The threat of decreased funding for research with consequent brain drain, aging of research facilities, difficulties recruiting new researchers and starting new research lines exists.

One notices concentration of human resources and facilities in Central Europe. We often face difficulty to be successful in European projects which require extensive networking.

SWOT REPORT ON NANO-CATALYSIS IN THE SUDOE REGION:

Brief introduction to the topic

The needs for alternative energy sources, on one side, and the growing environmental concerns, on the other, have led recently to a new impetus in catalysis. Since the end of the 90's, and with the development of nanosciences, a new field has emerged,"nanocatalysis". This new field appears as a domain at the interface between homogeneous and heterogeneous catalysis, which offer unique solutions to answer the demanding conditions for catalyst improvement, for example aiming at making catalytic reactions more selective and/or at making several transformations in one step. But, the development of "nanocatalysts" needs important efforts of synthesis, of characterization and of catalytic validation. The different research groups involved in the nanocatalysis theme of the SUDOE TRAIN^2 project offer the complementary competences and knowledge which are necessary to develop well-defined nanocatalysts that should be able to display the ensuing benefits of both homogenous and heterogeneous catalysts, namely high efficiency and selectivity, stability and easy recovery/recycling.

Strengths / *Nano-catalysis:*

Highly dedicated scientists and large infrastructures including various techniques and equipmentsexist in this topic.
There exists access to information through exchanges or meetings for example.
There are complementary competences amongst groups.
There are needs for a larger research knowledge-based catalysis
One can notice the existence of innovative research ideas in the area of advanced catalysis and green chemistry
All the aspects of nanocatalyis are concerned from synthesis aspect of complex nano-objects to their full characterization or their catalytic reactivity.
Expectations exist to expand nanocatalysis breakthroughs for further industrial and environmental exploration.
The SUDOE region is competitive in comparison with other areas in Europe.

Weaknesses / *Nano-catalysis:*

We notice a short duration of the TRAIN^2 project as exchanges take time and some are only starting.
There exists considerable and increasing burocracy work needing an incredible large number of researchers hours dedicated to reporting and managing.
We perceive the lack of strong links with industries and companies. There are difficulties in translating knowledge into economic activity.
There is lack of support for out reaching and dissemination of the research.
The budget for research is low.
We lack new positions for young researchers.

Opportunities / *Nano-catalysis:*

There are numerous opportunities for collaboration with high-quality researchers and in well-equipped centers.
Large contribution to the basic knowledge in the field of chemistry and catalysis exists; bridging and interlocking of the research institutions.
We are ready for training in fundamental and practical scientific research.
There exists potential development of research-to-business solutions.
There is a high quality level of the research developed which are timely and compare well to the best places in the world.
The association of the involved centers in TRAIN^2 project can make a very visible project which could be the basis in the future for example of a "Synergy" project of ERC.
The present economic situation makes even more necessary the development of alternative sources of energy and use of sustainable materials. This research line will be continued whatever the economic situation since it aims at reducing the cost of goods production and to limit its environmental impact.

Threats / *Nano-catalysis:*

The threat of increasing large bureaucracy and audits but lower funding exists. Funding is a real problem for research, in terms of available funding for maintenance and renewal of equipment and infrastructure, as well as human resources for scientists and technicians.
The possibility to loose bright researchers due to the lack of permanent positions exists.

SWOT REPORT ON MICRO- AND NANO-DEVICES IN THE SUDOE REGION:

Brief introduction to the topic

The SUDOE region has for long been very active in various scientific fields relying on, or aiming at developing, micro/nano-devices.Several Clean Room exist and serve research centers and universities. There is a strong relation between research and academia, with an important part of the research being carried out by universityprofessors and PhD students. The region is particularly focusing on five domains which are nanophotonics, plasmonics, applied magnetism, bio-inspired devices and micro/nanosystems.Both nanophotonics and plasmonics concern investigations into building, manipulating, and characterizing optically active nanostructures with a view to creating new capabilities in instrumentation for the nanoscale, chemical and biomedical sensing, information and communications technologies, enhanced solar cells and lighting, disease treatment, environmental remediation, and many other applications. Bio-inspired devices and systems aim at mimicking the behaviour of bio-systems to develop new functions or new approaches to existing functions in various non-biological domains Applied magnetism has several representatives within SUDOE region, with a consolidated independence in materials deposition, characterization and device top-down microfabricationtechniques.Micro/nano systems technology is applied to diverse areas, with special emphasis to the development of miniaturized sensors for (bio)chemical analysis and micromechanical sensors and actuators.

Strengths / Micro- and Nano-devices:

The SUDOE area holds a diversity of centers and infrastructures with state-of-the art equipment for the fabrication and characterization of molecular and other low-dimensional nano-systems. In addition, there is an interesting mix of newly created centers and consolidated centers that, in conjunction, they have an enormous potential for addressing new challenges in Nanotechnology. There is also a growing number of researchers and nano-related students that guarantees a proper use of these facilities.

There are highly-dedicated scientists, sufficient infrastructure and equipment and access to information, with high-quality international collaborations.

State-of-the-Art infrastructures and equipment are very expensive, and sharing among partners is a very good way to manage resources. On the other hand, students are sensitive to the broadEuropean space, thus can profit from the usage of the available resources within TRAIN^2 partners.

Advances in the fabrication of optical structures at the nanoscale and improved control of materials properties have allowed researchers to demonstrate and realize the potential of nanophotonics and plasmonics, and they provide strong impetus for further investments in these fields. Many groups in The SUDOE area (notably in France and in Spain) have developed a strong expertise in the simulation, engineering (both top-down and bottom-up approaches), structural and optical characterizations of these structures.

In the particular case of INESC-MN, they are well known worldwide on the micro- and nano- device fabrication, providing devices for other partners within many years of collaborations. This know-how is available within the TRAIN^2. On the other hand, CNM has developed a deep knowledge for complex micro/nano systems using combination of microelectronics technology and nanotechnology, with applications in many different areas, from fundamental research to industrial application.

SUDOE has a large technology facility in LAAS, Toulouse, with 1500 m^2 clean room devoted to the development of micro/nano devices. This facility belongs to the French national nanofabrication network (see http://www.rtb.cnrs.fr). It is equipped with state of the art nanofabrication tools. It is open to external projects on an application/selection basis. A lot of work is being done on MEMS/NEMS, photonic devices and bio-inspired devices. In addition, there is a smaller technology facility in Montpellier which belongs to the French "local" technology network. It is equipped with standard technology tools which allow to develop processes and devices down to the submicron level. It is also open to external projects. This facility is strong in the development of MEMS and infrared photonic devices. Finally, another "local" technology facility will be built in Bordeaux in the near future. Among the strength of the Region, UM2 is well known worldwide for its work on infrared optoelectronics devices as well as in MEMS accelerometers. The Clean Room facilities at CNM (Barcelona) to develop this topic are also large. In addition, there are several other well-equipped facilities for micro/nano fabrication in the SUDOE area that complement the possibilities for fabrication and development of micro/nano devices.

Weaknesses / Micro- and Nano-devices:

There is lack of identified industries in the SUDOE area that could take direct benefit from the research activities and define research lines of industrial applications

There existsconsiderable and increasing bureaucratic work with an incredible large number of researchers hours dedicated to reporting and managing, with extremely complicate and lengthy reporting procedures. There is lack of flexibility.

The local industrial network directly involved in the development/study/use of innovative micro/nano devices remains weak in the Languedoc-Roussillon region.

The existent facilities are very much research-oriented, rather than industry-oriented. Many excellent research centres have no links to applied fields. Other European countries (eg. Germany) have good support from industry, and the basic research is driven by industrial needs, which is not the case of some partners. Also, Universities usually provide week training on this area, which highly motivated this TRAIN^2 project

There is decreasing funding to research projects and fellowships for the training of new researchers from European and National governments due to the financial crisis.

There aredifficulties to attract the interest of the local industry and lack of identified companies in the SUDOE area that could take direct benefit of the research activities and define applications of their interest.

There is an increasing need for characterization tools that can correlate the structural and materials properties at the atomic-scale to the functional properties of devices.

Opportunities / Micro- and Nano-devices:

There are big opportunities for addressing scientific and technological challenges through collaboration and networking between the different entities involved in Nanoscience and Nanotechnology in the SUDOE area. There is potential in terms of researchers and infrastructure to create a cluster competitive at the European and World level. There are big opportunities for collaboration with high-quality researchers and in well-equipped centers

If the exchange of knowledge is efficient (through people mobility and resource sharing), the final result can indeed be a dynamic line of tools made available at the university and research centers within the SUDOE region.

The European community has been active in developing strategic roadmaps in photonics, nanoelectronics, nano/microsystems and nanotechnology. The MONA (Merging Optics and Nanotechnologies) consortium, launched in June 2005, developed a roadmap for photonics and nanotechnologies in Europe by involving several hundred researchers in industry and academia, In addition, an “Emerging Nanophotonics Roadmap” has been formulated by the members of the EU Network of Excellence in

NanoPhotonics to Realize Molecular Scale Technologies (PhoReMoST). In the SUDOE area, the emergence of collaborative research environments would promote rapid advances in this field. Important applications and goals for nanophotonics in thenext ten years are the all-optical chip, metamaterials operating at visible wavelengths, single-(bio)molecule detection, artificial photosynthetic systems for energy applications. The collaboration (sharing of information, construction of joint databases), networked fabrication, metrology, and characterization resources, the wider availability of open-source, multiscale computational tools (especially for designing nanophotonic circuits) are important factors in order to successfully reach these goals. Within the ICT program, funding of research projects in the fields of nanoelectronics and Micro/nanossytems technology will continue in the Horizon 2020.

The combination of the different technology facilities gives SUDOE unique opportunities to develop original and innovative devices. TRAIN^2 offers the opportunity to create a SUDOE cluster dedicated to the micro/nano-devices which can rival other such clusters and somewhat re-equilibrate the European scheme.

There arealso opportunities to contact companies that could be interested in our research.

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Threats / Micro- and Nano-devices:

In view of present economic situation, there is a big threat of a decrease of available funding for maintenance and renewal of equipment and infrastructure, and human resources for scientist and technicians. These would now allow the SUDOE area to be in a competitive level in comparison with other areas in Europe

The increasing large bureaucracy and audits combined with lower funding is a real threat.

In view of present economic situation, in order to get full benefits of innovation in photonics and plasmonics to the breadth ofpotential fields related to energy-efficient devices (e.g., photovoltaics) and biomedical research (e.g., imaging), it is essential of making broadly available a common infrastructure platform for materials synthesis, nanoscale fabrication, and characterization.

The effort of sharing infrastructures can fail, when partners are located far away from each other. In addition, the number of people involved must be large enough, to cope for unsuccessful collaborative trials (eg.: a student spends some time in another location, but at the end he decides to move to another subject).

There is a risk that this activity be considered as marginal in Europe if clustering of infrastructures is not effective or fail.