NANOLITO NETWORK
Zaragossa 26th may 2009

The technical support in a French
Technology Platform of the Basic Technological Research Network
The example of LAAS-CNRS

Laboratory for Analysis and Architecture of Systems

Research topics

The people

The structure

Technicals means

LAAS : SYSTEMS and APPLICATIONS

- **Kinds of systems**
  - Micro and nano systems
  - Embedded Systems
  - Integrated Systems
  - Large Scale distributed Systems
  - Biological Systems
  - Mobiles Systems
  - Autonomous Systems
  - Critical Infrastructures

- **Applications**
  - Aeronautics
  - Space
  - Transports
  - Energies
  - Services
  - Health
  - Telecommunications
  - Environment
  - Production
  - Military

LAAS : THE PEOPLE

Searchers : 534

86 CNRS, 1 INSERM

105 Professors-searchers

9 CNRS hosts

1 detached from industry

7 contractual searchers

6 Associated serachers

44 Post-Phd

273 PHD

2 CNAM (continuous formation)

Technical Staff : 115

87 ITA (CNRS)

5 ITAOS (University/Engineers school)

23 Contractuals

649

At the 1st of January 2009

LAAS : STRUCTURE

Direction
R. Chatila
J-L. Sanchez

General Secretary
A. Filipowicz

Groups of research	Thematic Areas	
ISGE, M2D, MINC, MOST, N2IS, NBS, PHOTO	MINAS	Micro and Nano Systems *A-M. Gué*
DISCO, MAC, MOGISA, MRS	MOCOSY	Modelling, Optimisation and Control of Systems *L. Travé Massuyès*
GEPETTO, RAP, RIS	RIA	Robotics and Artificial Intelligence *R. Alami*
CDA, ISI, OLC, TSF	SINC	Critical Information Systems *J. Arlat*

Technical Services

II
Computing and instruments

TEAM
Technics and Equipments Applied to Microelectronics

Administrative services:
Financial
Contractual Relations and partnerships
Human ressources
Support Services :
Library-Edition
Information Systems
Logistics Services :
Logistic
Store

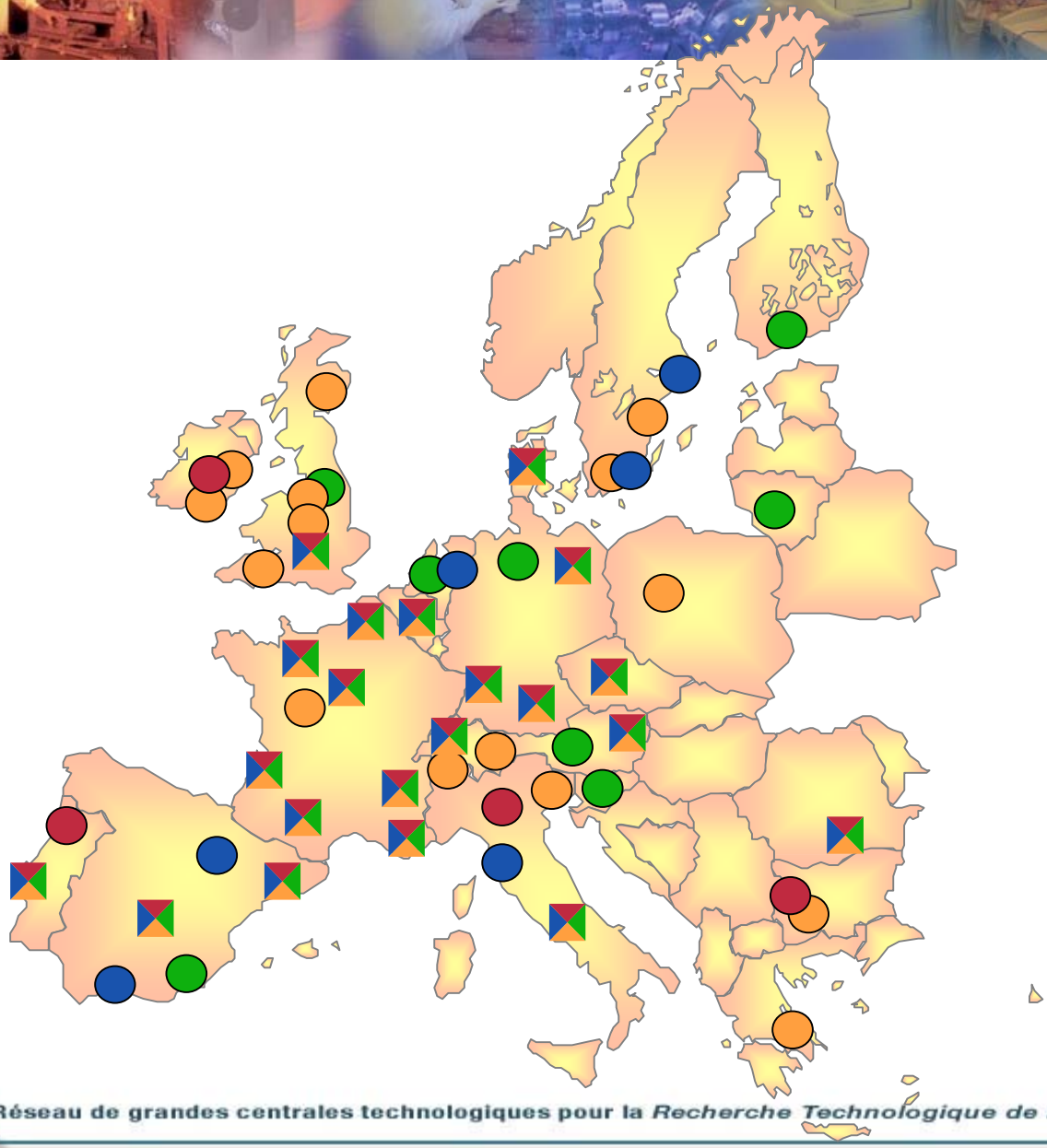
Services

LAAS : TECHNICAL MEANS

- **BTR technological platform :** microelectronics, optoelectronics components, micro and nano systems
- **Characterization platform:** components tests, micro-nano systems: electronic, optical, UHF
- **Robotic platform:** a tenth of robots
- **Micro systems conception platform**
  - Methodologies
  - Industrials and Research softwares
- **"Network" platform**
  - Experimental validation on complexes architectures
  - Metrologies, modelling, security
- **"Embedded Systems" platform**
  - Software Integrations, captors, actuators, dynamic modelling of "embedding" systems, Conception Industrials and Research softwares

CPER
2007-2013
« ADREAM »

EUROPEAN COLLABORATIONS



SUPPORT TO MICRO AND NANO SYSTEMS DEVELOPMENTS

The technology platform

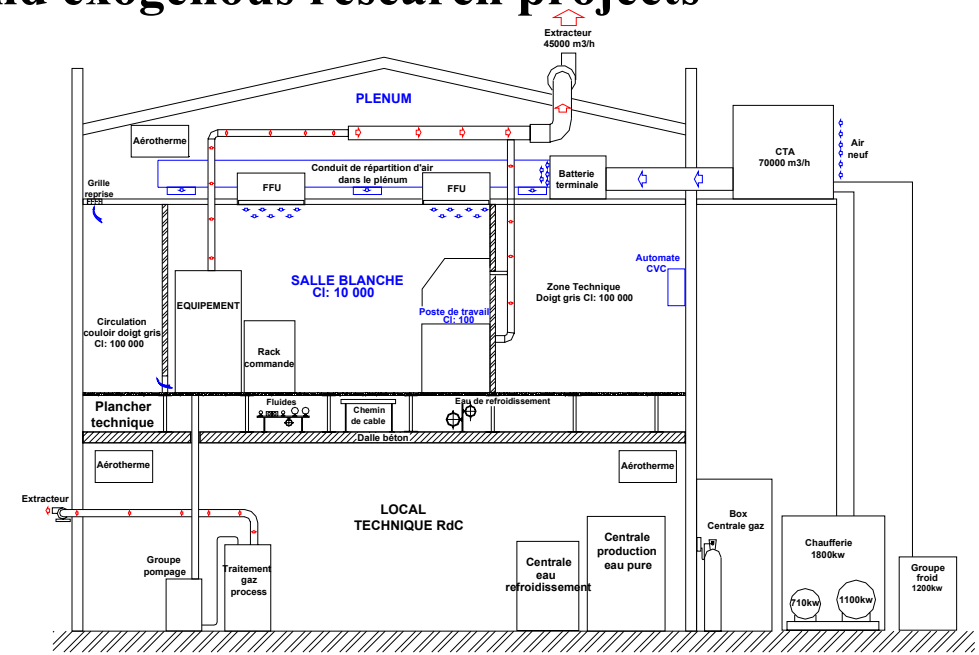
The technical staff

THE TECHNOLOGY PLATFORM

Facilities

Support endogenous and exogenous research projects

- Adaptative structure
  - 4 levels architecture
- 1500 m² clean room
  - Specialized areas
- From class 10 000 up to class 100
  - Upgradeable (Filter Fan Units)
- Control of running costs
  - 1.5 M€ in 2008

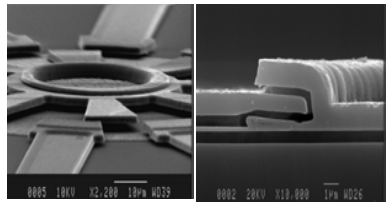


Investments

- Since 2003 : 16.5 M€ (half from LAAS own resources)
- Building : 2.4 M€ (CPER) + 3.9 M€ (RTB)
- Equipment : 10.2 M€

THE TECHNOLOGY PLATFORM

– 25 M€ equipment total value
– Equipments policy
  • Manuals / Semiautomatic /Automatic equipments
– Si and III-V technologies
  • (Diamond, GaN, polymers,…)
– 4'' Si wafers (upgradeable to 6 '')
– Developments in substitution technologies



To Caracterization

Packaging

Ion implantation

Electrochemical deposition

Plasma Etching

Metallization

M.B.E.

Wet Etching

Chemistry

Thin films deposition

Electronic lithography

Optical photolithography

Infrastructure and support

From Mask fabrication

EQUIPMENTS POLICY

Complementary equipments for an adapted support

Flexibility
(adaptability to projects)
vs.
Specificity
(axes)

Development
(parameters understanding, prototyping)
vs.
Repeatability
(Formalization, valorization)

Constant investments (more then 3 M€ in 2007)

- BTR Conventions
- Institutional (CNRS, Region,..)
- Collaborations et partnerships (ANR, Europe, .., common, affiliates club, …)
- Own resources (COMEQ, general interest of the laboratory)

A planning taking into account

The necessary youth of some equipments
"Alternative" technologies

Technical developments
Technical prospective

MATERIAL ELABORATION

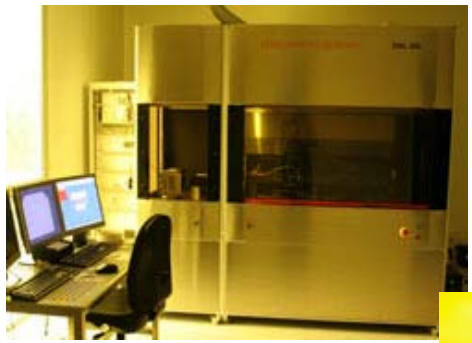
- **Molecular Beam Epitaxy**
  (GaAs based)
  - Photonics structures
  - Surface nano structurations

- **Furnaces**
  - Oxidation Si, III-V alloys (Al based)
  - SiO_xN_y
  - Si3N4
  - Sipoly
  - LPCVD

- **Chemistry**
  - **Sol gel, polymers, …**
  - **Synthesis Developments**

MATERIAL « SHAPING »

- **Lithography**



Masks fabrication

1-2 µm

Optical photolithography

0.3 - 0.4 µm

Projection lithography

30 nm

Electron Beam Lithography

Nano replication (in 2009)

MATERIAL « SHAPING »

- **Etching**

  DRIE

  (Si 4'', 6'' and glass)

  ICP

  (Si and derivate, III-V, Polymers, metals)

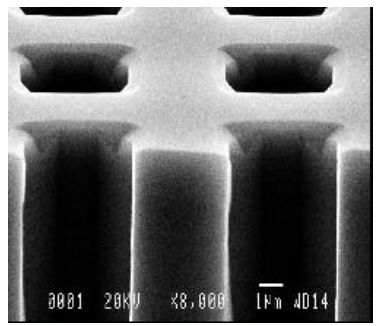
  Stripping

  Chemistry

  (metals, resists,..)

  KOH, TMAH

  Vapor phase (in 2009)



MATERIAL « SHAPING »

- **Deposition**

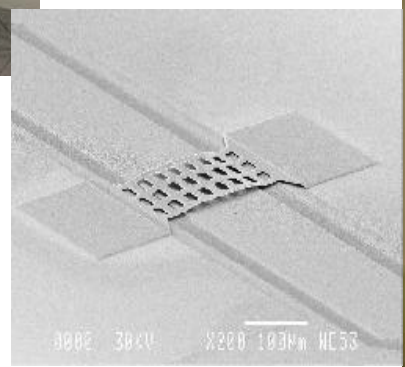
PVD

Electrochemistry

(Au, Cu, magnetic alloy)

PECVD

(SiO2, Si3N4)



LPCVD

SiOxNy, Si3N4, Si poly

MATERIAL « SHAPING »

- **Packaging**

  Dicing

  Pick and place

  (manual, semi-auto)

  Connexion

  (wires, flip chip)

  WLP

  (CMP, grinding, Wafer bonding)

MATERIAL TREATMENT

- **Thermal**
  (Annealing, RTA, diffusion, redistribution)

- **For surface preparation**
  (plasma, chemical)

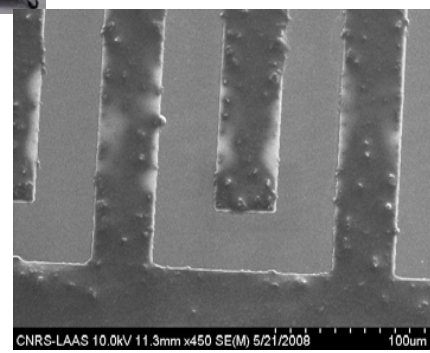
- **Ion Implantation**

CHARACTERIZATION

- **2 SEM**
  (X surface analysis, variable pressure)
- **AFM**
- **Optical Microscopy**
  (2D, 3D)
- **Profilometers**
- **Ellipsometers**
- **4 probes**

A CONSTANT EVOLUTION

- **ALTERNATIVES TECHNOLOGIES**
  - **Ink Jet**
  - **Screen printing**
  - **Nano replication**
    - **UV NIL**



- **UP TO COME**
  - **Low T° PECVD**
  - **1800° C furnace**
  - **Spray coater**
  - **Vapor phase etching**
  - **Wafer bonding (duplication)**
  - **Nano replication**
    - **Micro contact printing**
    - **Hot embossing**
  - **AVD (OMCVD or ALD?)**

THE STAFF

Technics and Equipments Applied to Microelectronics

30 Engineers, Engineer Assistants and Technicians directly under the authority of the director

Area Responsible Mask fabrication

Area Responsible Photolithography

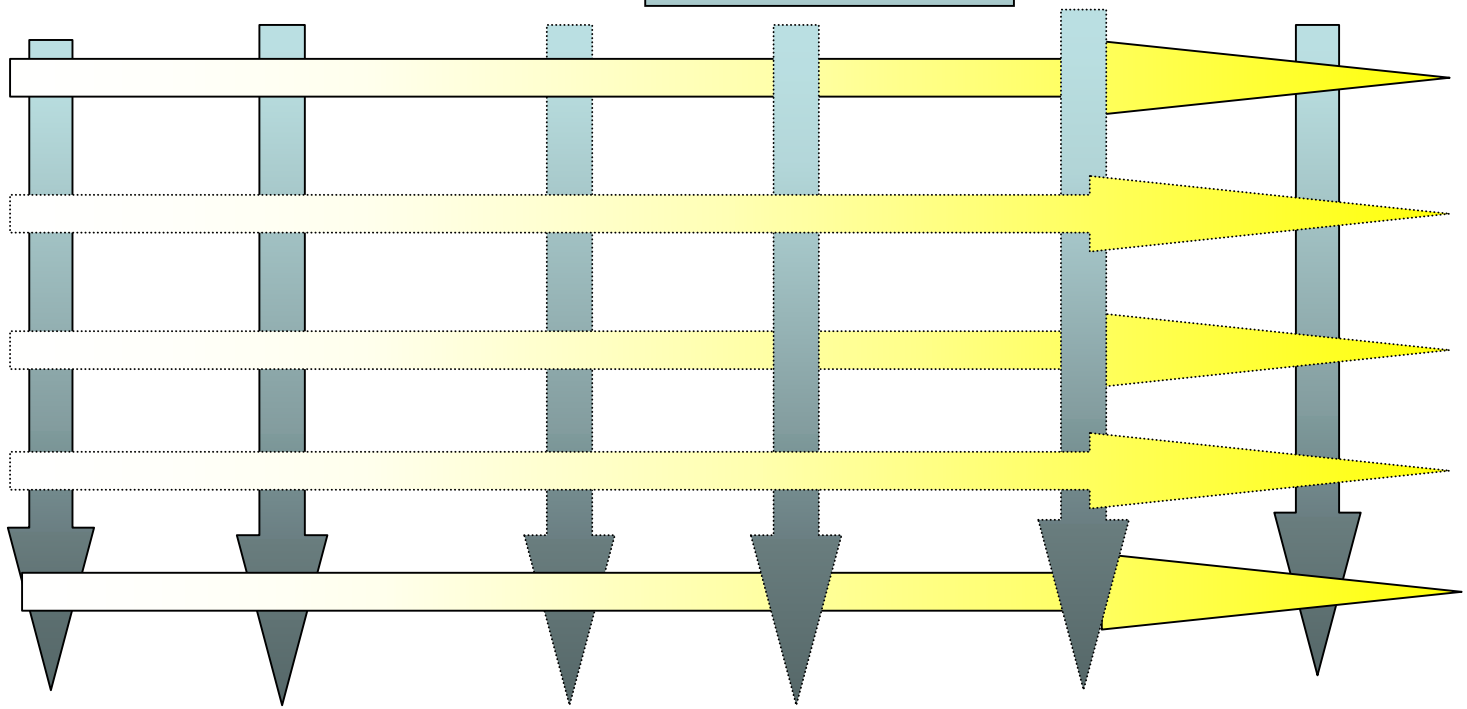
Responsibilities
- **Equipments**
- **Processes**
- **Formation**

Area Responsible PVD

LAAS projects coordination

- **Technological managing**
- **Process development**
- **Expertise**

BTR projects coordination



TEAM : IDENTIFIED COMPETANCIES

Elaboration, shaping, treatment et characterization of materials

Elaboration				■	■	■		■				■	
shaping,	■	■	■	■	■		■	■	■	■		■	■
treatment					■	■			■		■		

In technical areas, open to all projects

Infrastructure and Support	Mask Fabrication	Photo -lithography	Electron beam lithography	Molecular Beam Epitaxy	Chemistry	Thermal Treatments	PVD	Electro-chemistry - Si wet etching	Plasma etching	Packaging	Ion Implantation	Ink Jet	Nano replication
Fadel Paul IE2 **Benoit** Monique TCE **Maiorano** Antoine TCN **Fourcade** Christine TCN	**Calmon** Pierre François. IR2 **Aouba**[1] Stéphane IR2	**Conédéra** Véronique IR1 **Mazenq** Laurent AI **Mesnilgrente** Fabien AI	**Carcenac** Franck IR2 **Daran** Emmanuelle IR1	**Arnoult** Alexandre IR2 **Lacoste** Guy IE2	**Doucet** Jean Baptiste IE2 **Mesnilgrente** Fabien AI	**Rousset** Bernard IR1 **Bouscayrol** Laurent AI	**Salvagnac** Ludovic AI **Pinaud** Sébastien AI	**Dilhan** Monique IR2 **Bourrier** David AI	**Dubreuil** Pascal IR2 **Belharet**[1] Djaffar IR2 **Jalabert**[2] Laurent IR2	**Granier** Hugues IR2 **Do Conto** Thierry TCE **Colin** René AJTP2 **Charlot**[1] Samuel IE2	**Imbernon** Eric IR2 **Marrot** Jean Christophe TCE	**Fabre** Norbert IRHC **Conédéra** Véronique IR1 **Mesnil-grente** Fabien AI	**Daran** Emmanuelle IR1 **Jalabert**[2] Laurent IR2

1 : Contractual
2 : Detached at LIMMS in Tokyo

TEAM : PRECISE MISSIONS

- **Responsibility for the equipment**
  - Implementation, safety
  - Maintenance, evolutions
  - Appraises and technical survey

- **Responsibility for operation of the clean room infrastructure**
  - Adaptation, development and maintenance
  - Management of the tasks of general interest (management of process gas, safety, provisioning, etc…)

- **Support to MINAS research projects**
  - Development of basic and specific processes (70 projects in 2009)
  - Coordination, participation in the technological realizations
  - Assistance, technical management of the PHD

- **Hosting and support of exogenous projects (nearly 50 in 2008) (member of network RTB)**
  - Expertise/administration of the requests
  - Interactions with the applicants
  - Hosting /formation of external people
  - Realization of the projects

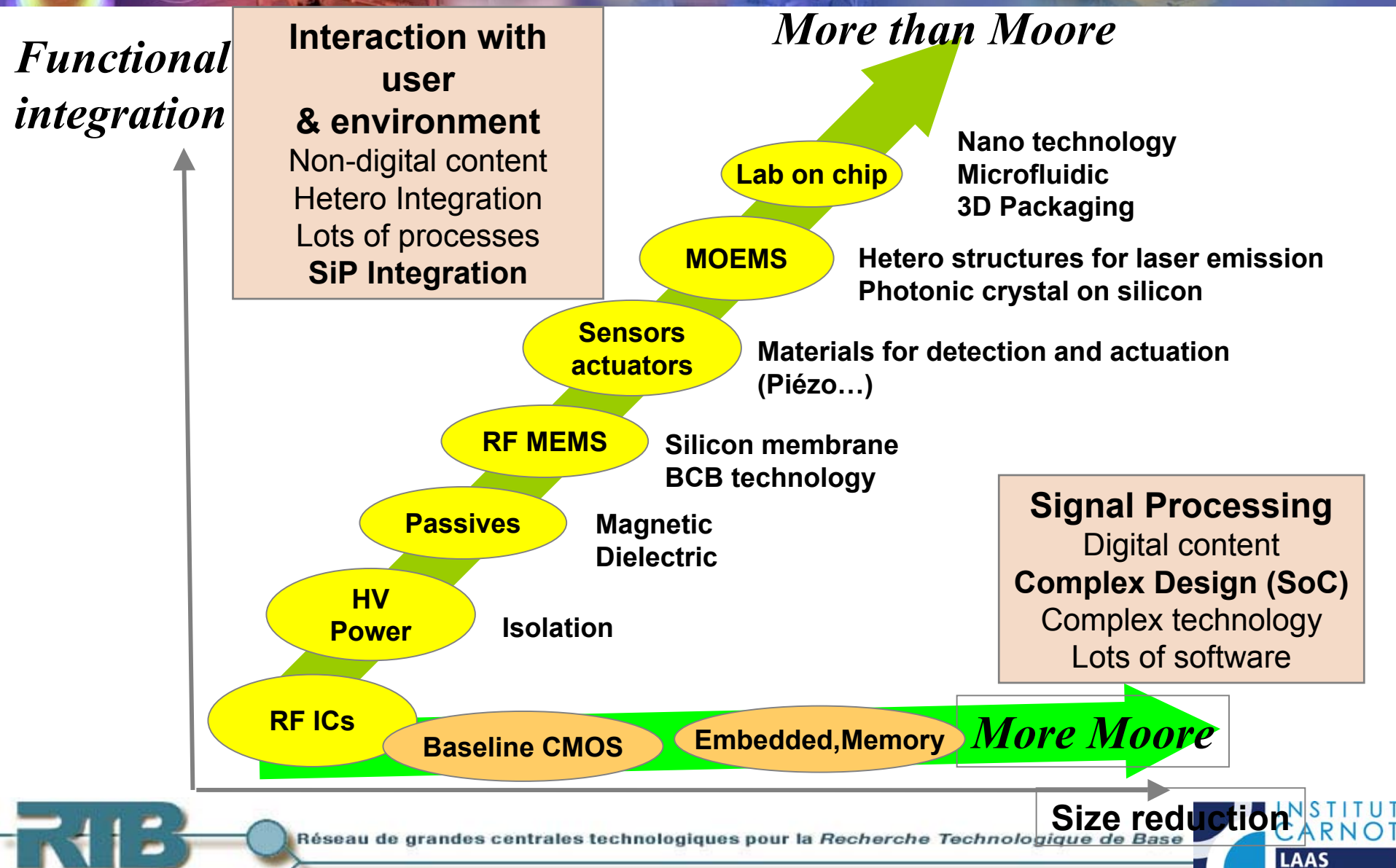
- **Formation, capitalization, valorization and transfer**

THE PROJECTS
From the lab
From the BTR network

Origins
The management
Some examples

INTERNAL PROJECTS FROM MINAS

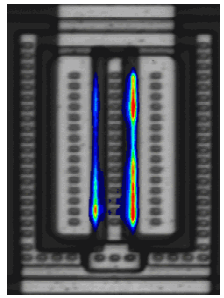
Bridging the Gap between Chip and Application

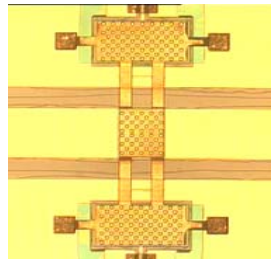


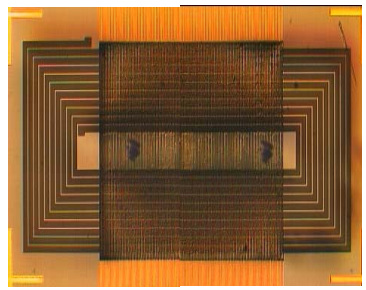
INTERNAL PROJECTS : RESEARCH GROUPS

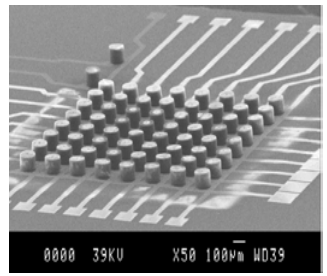
MINAS: Micro Nano Systems

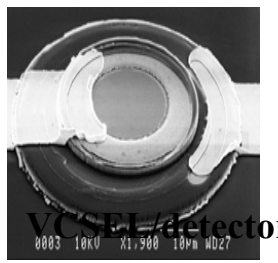
- ISGE: Power Integration and management Systems
- M2D: Detection Micro devices and Microsystems
- MINC: Micro nano systems for communications
- N2IS: Nano Engineering and Systems Integration
- MOST: Microwaves and optronics for communication systems
- NBS: Nano biosystems
- PHOTO: Photonics



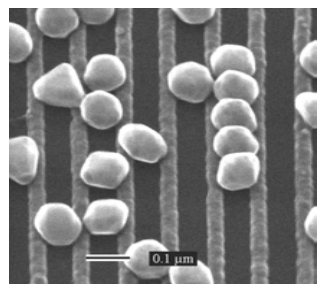






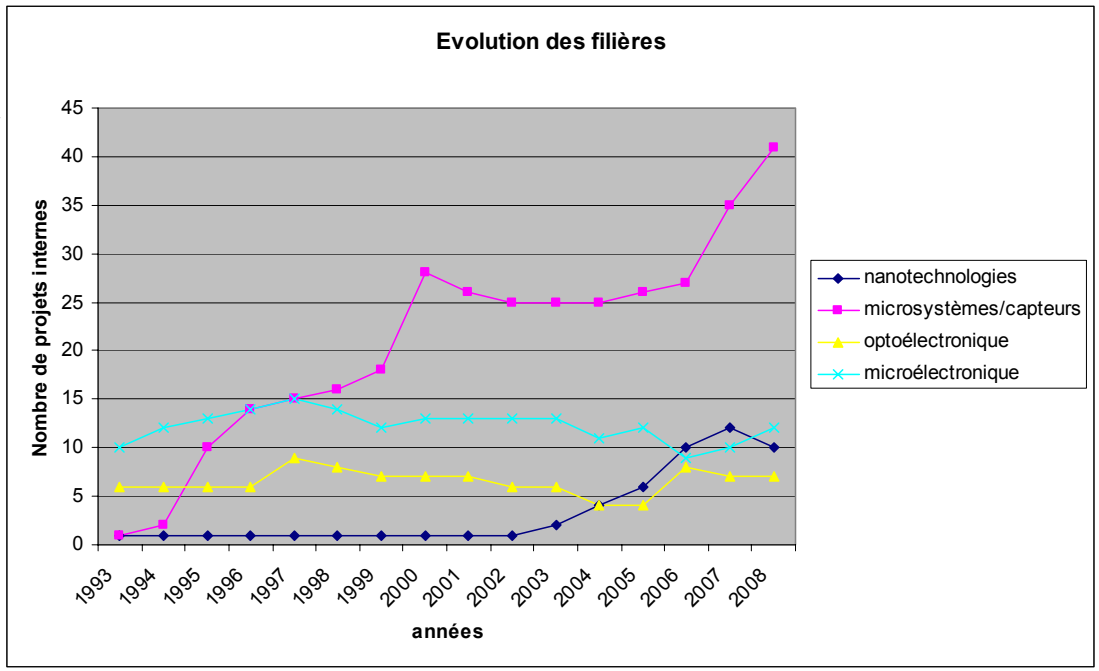


VCSEL / detector



INTERNAL PROJECTS : MANAGEMENT

- COMTEAM
  - Under the presidency of the director
  - Analyze the projects
  - Activities of general interest
  - Calculation of IT needed implications
  - Activities analyze
  - Analyze BTR actions
  - Helps to define :
    - Lacks of IT
    - Needed equipments
    - Inventories and evolution of projects



EXTERNAL PROJECTS : BTR NETWORK : GENESIS AND OBJECTIVES

- **2003 Dedicated program decided by Ministry of Research:**

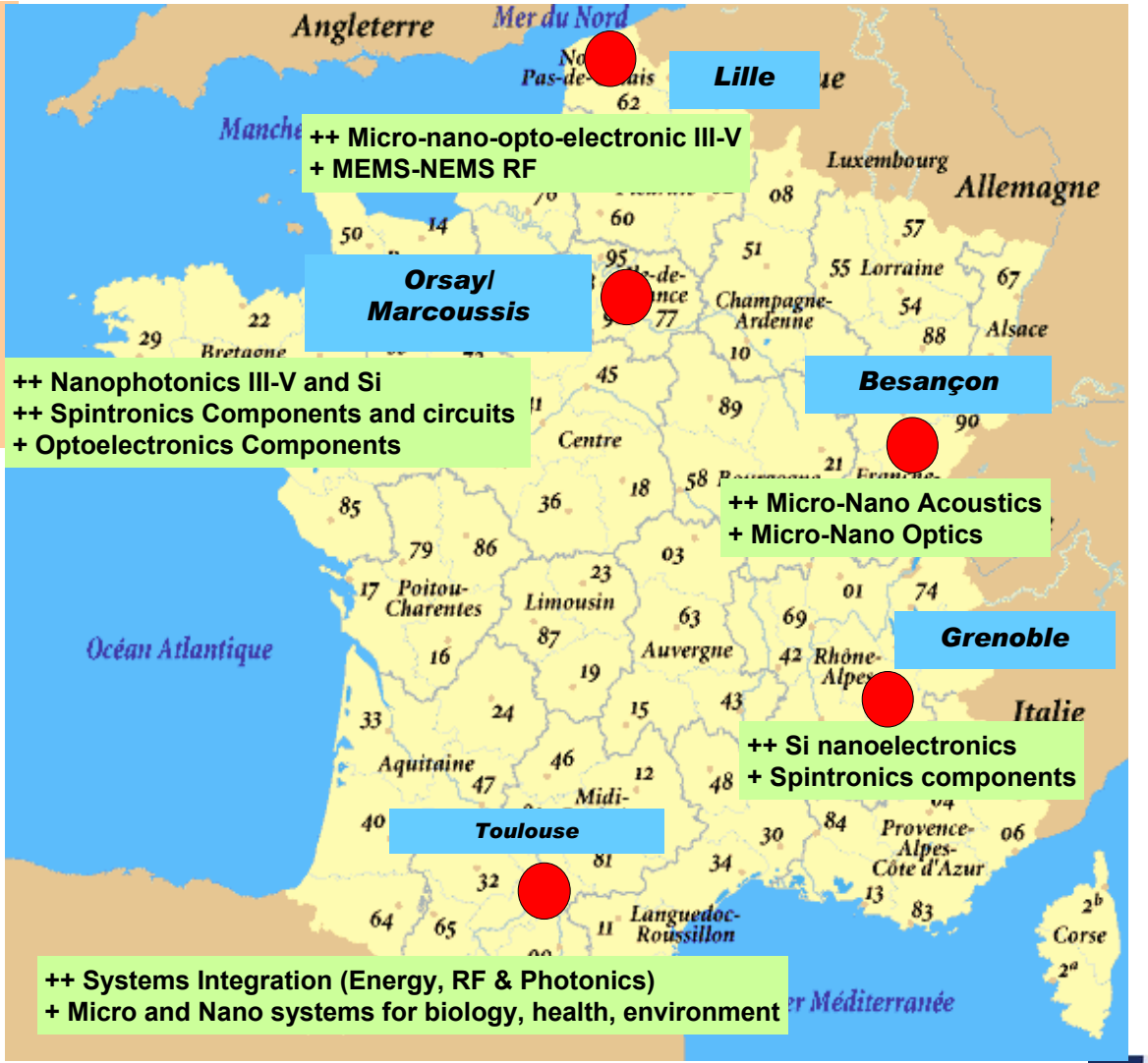
"A national network of large technological facilities and Basic Technological Research (BTR) in micro and nanotechnologies "

- 100 M€ **National program leaded by CEA and CNRS (Renatech GIS)**

- **3 different complementary objectives.**
- **To enhance the level of equipment**
  - **A few selected clean rooms in France (so-called large technological facilities)**
  - **A network, open to the need of the academic scientific community and of industrial research projects.**
- **To focus a scientific program on few priority areas**
  - **Micro- and Nanoelectronics, Nanosciences and Nanotechnologies, Photonics and optoelectronics, Micro Nano and Biosystems and Heterogeneous integration of technologies**
- **To enhance the use of joint vision and exploitation of research results**
  - **Setting up a unit, in charge of the scientific survey in the field of Micro and Nanotechnologies (OMNT).**
  - **Promoting patenting and researcher mobility.**

EXTERNAL PROJECTS
BTR FACILITIES

- 6 CNRS laboratories (GIS RENATECH)
  - IEMN (Lille),
  - LAAS (Toulouse),
  - FEMTO (Besançon),
  - FMNT-INAC (Grenoble),
  - LPN (Marcoussis)
  - IEF (Orsay)



CEA-LETI (Grenoble)
++ Above IC
++ Microelectronics
++ Photonics
+ Biochips

EXTERNAL PROJECTS
BTR NETWORK : FACILITY OPENING TO ACADEMIC AND INDUSTRIAL COMMUNITY

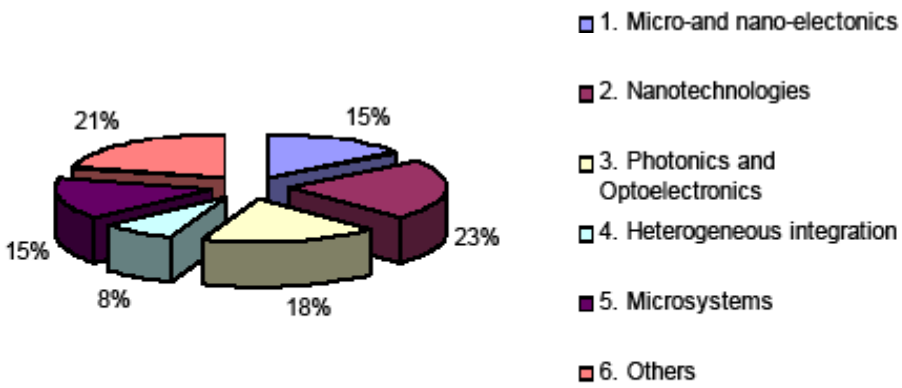
- **For each platform**
  - **A team to receive the proposed projects.**
  - **Technological feasibility and cost evaluation.**
  - **Agreement for cost supporting to be defined between the proposer and the platform.**
  - **Training programs for the proposer to participate actively to the execution of the process**

- **Common tools**
  - **Centralized network administration via the administrative manager**
  - **A WEB site:www.rtb.cnrs.frwww.fr (also limited English version)**
  - **Definition of external projects and evaluation criteria.“Charte d’accueil”.**
  - **E-mail alias for project dispatching (rtb-accueil@cnrs-dir.fr).**
  - **Annual meeting to discuss external project reception.**
  - **Technical meetings for expertise enhancement.**
  - **Centralized annual survey of external projects.**
  - **Satisfaction questionnaire addressed to the external users.**

- **Evaluation of the network**
  - **Annual report to internationals experts**

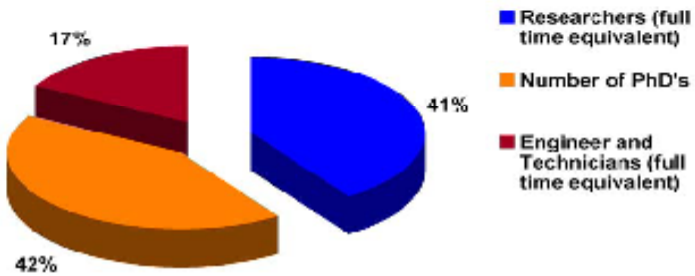
EXTERNAL PROJECTS
BTR NETWORK : SUMMARY 2008

- **289 external projects performed in the network by the CNRS platforms.**



RENATECH

BTR NETWORK : PEOPLE INVOLVED IN TECHNOLOGICAL RESEARCH



BTR lab	Researchers (full time equivalent)	Number of PhD's	Engineer and Technicians (full time equivalent)
FEMTO-ST	32	45	14
FMNT	95 (1)	100	33
IEMN	60	88	21
IEF	34	15	15
LPN	41	14	25
LAAS	57	73	25
CNRS-ST2I			1
TOTAL	**319**	**335**	**134**

(1) **The platform is not fully operational. The number is a prediction**

RENATECH

BTR NETWORK : SHARING A TECHNICAL EXPERTISE

- Since 2004 : internal technical work groups on process know-how
  (resp. leaders: J.L. Lorriaux, IEMN, F. Hamouda, IEF, H. Granier, LAAS)
  - LITHOGRAPHY PROCESSES
    - Electronic lithography, U.V. and nano-printing.
  - DEPOSITION PROCESSES
    - Stress measurement, equipments for thin layer characterization, and electrolytic deposit, surface modification by chemical treatment, inkjet printing
  - ETCHING TECHNIQUES
    - Ion beam etching systems (FIB, IBE), end point detection systems, assembly techniques.
- This provides a links between engineers and technicians of all the facilities.
  - Dedicated workshops for the diffusion of information (1/yr)
  - Networking for the purchase of equipments (diffusion of information, grouped purchases)
- Enhancement of the global competence level and the cooperation between facilities.
  - Training

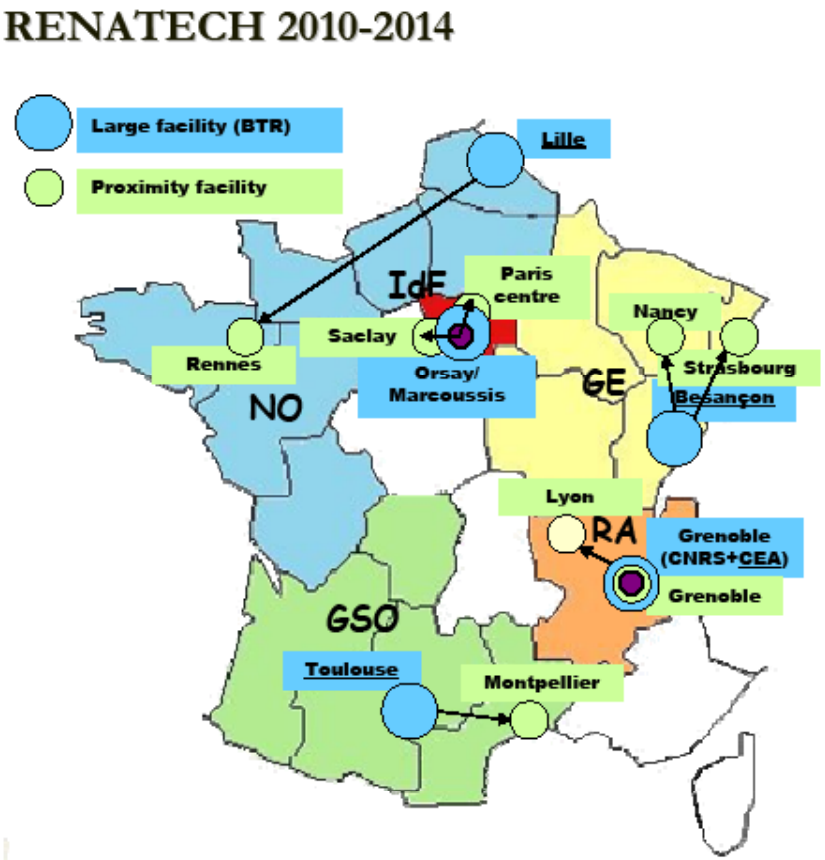
RENATECH

BTR NETWORK : THE FUTURE

- The main platforms of Renatech dispatched over the country
  - Each platform is the regional reference with a large coverage of the technologies

  + proximity platforms
  - With specialists in well defined fields

- Double coordination
  - Regional : main and proximity platform associated
  - National : CEA-CNRS



RENATECH

EXTERNAL PROJECTS
THE LAAS PROCEDURE

External proposer

plateformertb@laas.fr

Administrative
Technical feasibility
analysis
Cost evaluation

Host structure : 8IT from TEAM
For each project identification in the service of a coordinator

Contacts with other BTR facilities

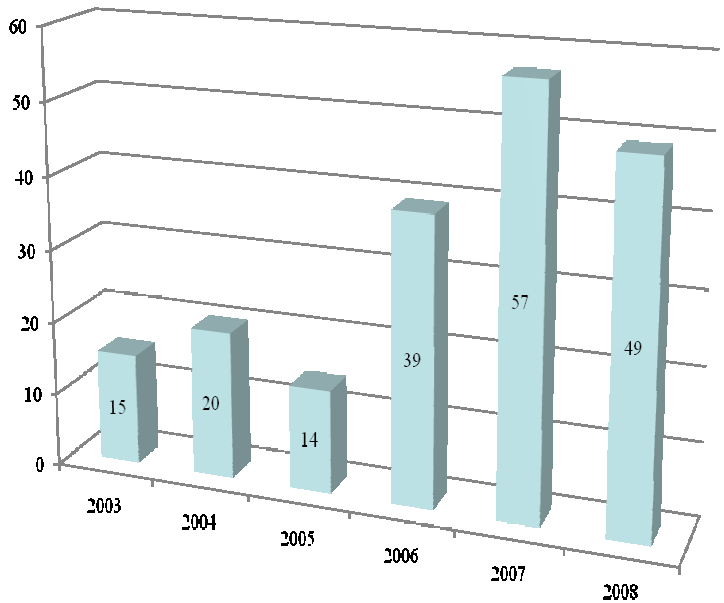
Support Developments

Developments in the scientific axis of the laboratory

Scientific collaboration

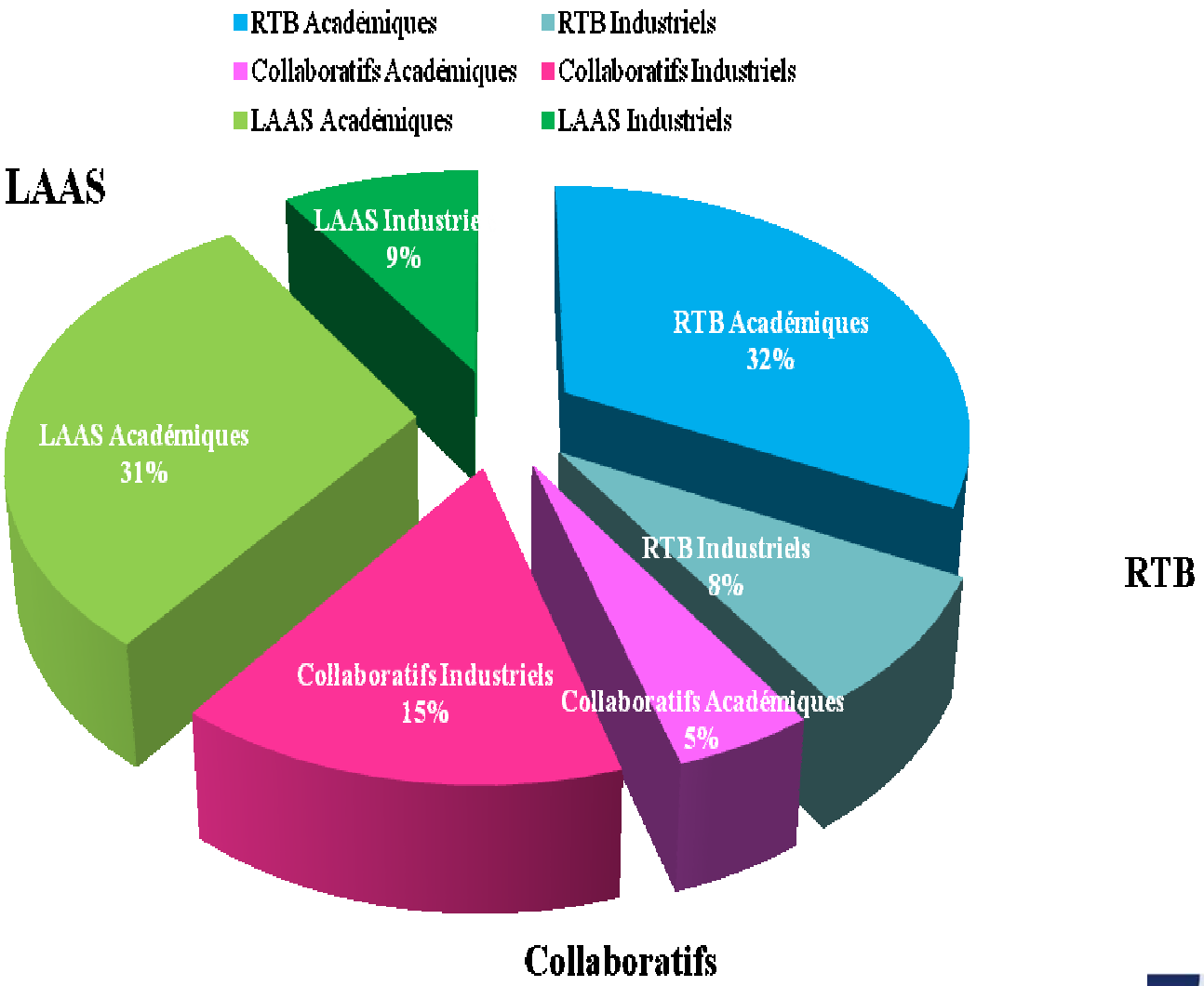
Realization
Internal
and/or
Participation of the proposer

Sending of the components
Cost- Valorization



Pure exogenous projects evolution

THE PROJECTS THEIR ORIGIN



Technological families

Biology, health	MEMs/NEMs RF	Photonic	Energy
- Micro/nanofluidic - Detection - Nanobiosystems	- Microfabrication - Nanotechnologies - Above IC	-Optical sources -Integrated functions	- Conversion - Harvesting , Storage
Basic steps + Specific steps	Basic steps + Specific steps	Basic steps + Specific steps	Basic steps + Specific steps

Technologies for N/MEMS

Micro an nano systems: biology, health, environment

Micro nanofluidics

Multilevel polymer technology

Surface nano-engineering

- Grafting technologies: silanes UV photografting
- Switchable surfaces

Actuation of fluids and molecules :

- Actuators: Microarray of individually addressable ejectors, Pyrotechnic valves, Flow monitoring using stimuli-responsive SAMs
- Flow engineering using active molecular layers
- Magnetic actuation
- Thermal engineering

Nanofluidics :

- Di phasic nanofluidics for optics
- DNA combing for replication study

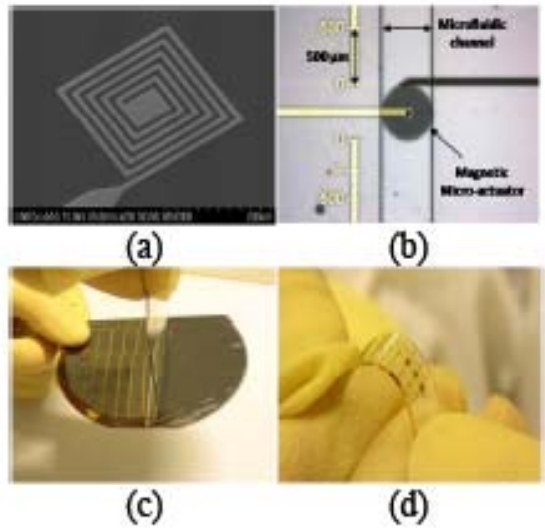
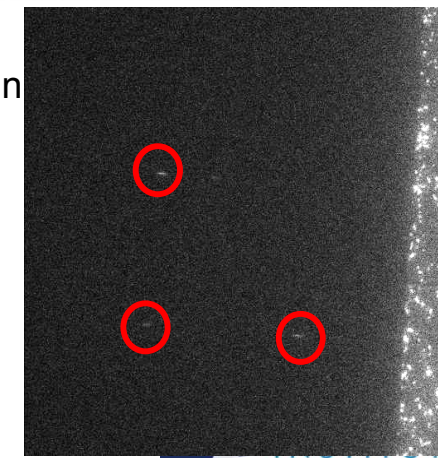
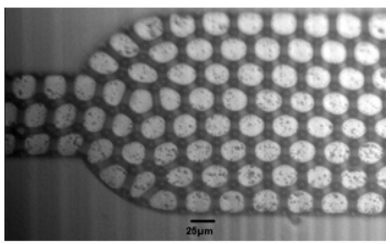


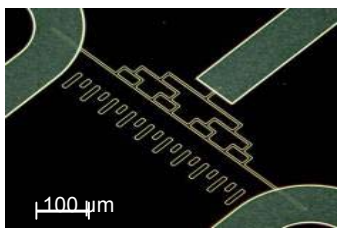
Figure 2 Photographs of the final flexible microsystem. (a) A square magnetic micro-actuator with 5 turns; (b) A spiral micro-inductor embedded in micro-channel. (c) The final step to the technological process: releasing from silicon.

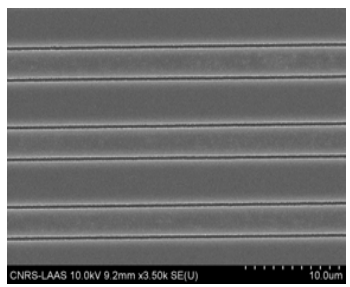
Diect imaging of DNA macromolecules sterched in nnochannels





fraction volumique elevée,géométrie en T bull

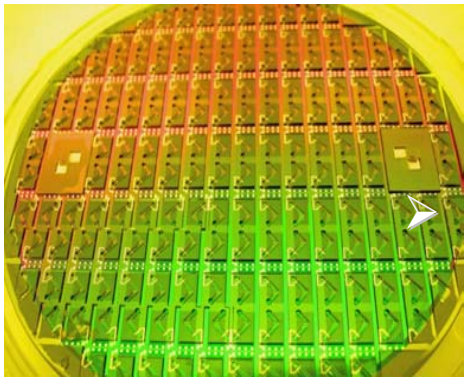




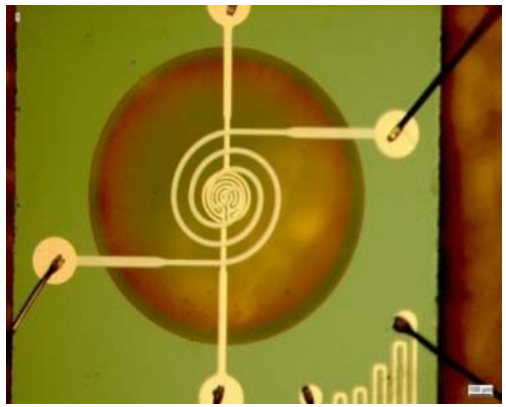
Micro an nano systems: biology, health, environment

Détection

Detection

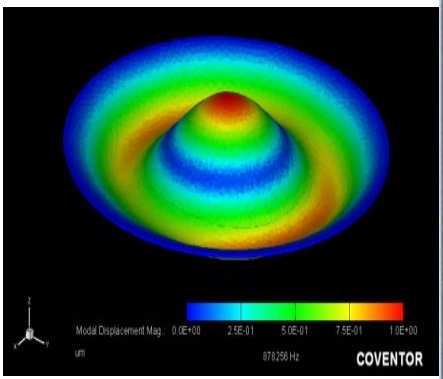


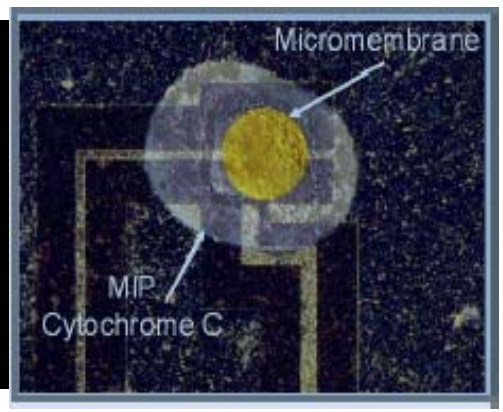
ChemFET



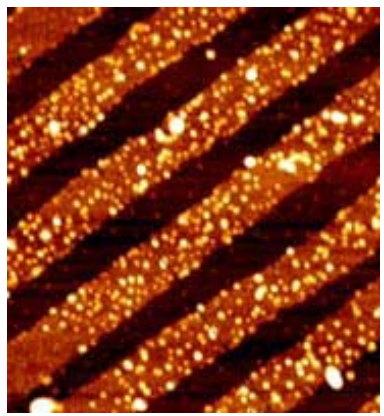
Gaz microsensor

Pressure microsensor

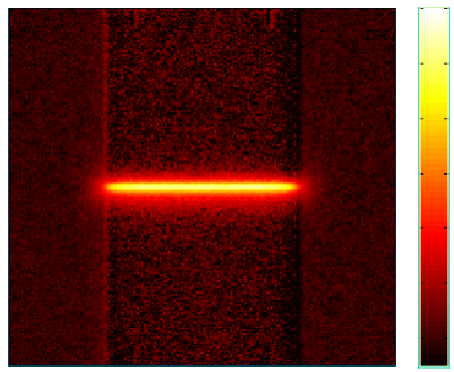




Electromechanic Transduction
(piezoelectric)



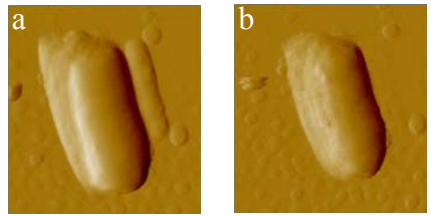
Optical transduction
(diffraction)



Electro-themal transduction
(silicon nanowire)

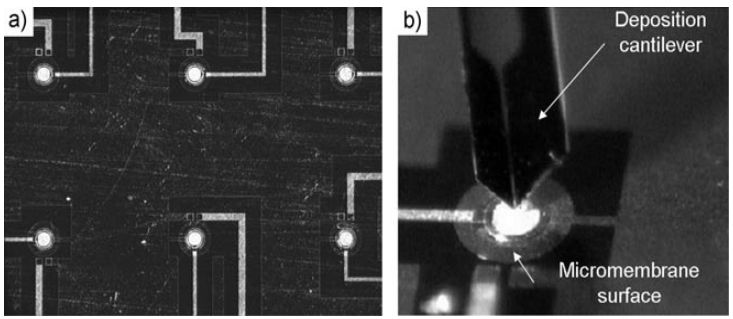
NanoBioSystems

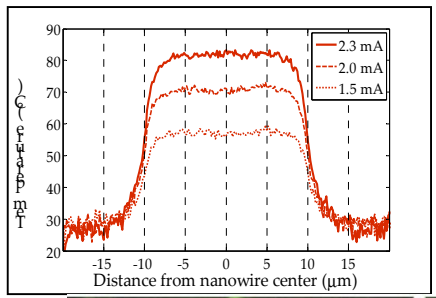
Nanobiosystems' road-map is « DNA-like » double-stranded:
- BIOLOGY-related issues using NANOSYSTEMS
- NANOSYSTEMS-related issues being inspired by BIOLOGY.

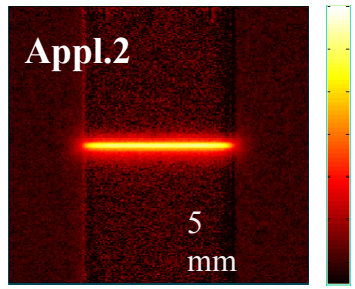


- Nanowires for highly resolutive thermometry
- Bioplume: submicron-scale liquid-phase deposition of various materials
- DifraChip: using nanoscale patterning for label-free detection (limit of detection : 100pM)
- Exploring living cells at the nanoscale (yeast, bacteria, fibroblast)

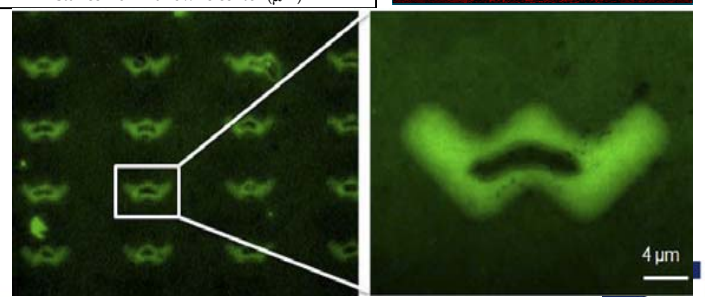
Images of a) a matrix of piezoelectric micromembranes with a global radius of 100 µm and b) a cantilever loaded with MIP precursor solution during deposition onto a micromembrane





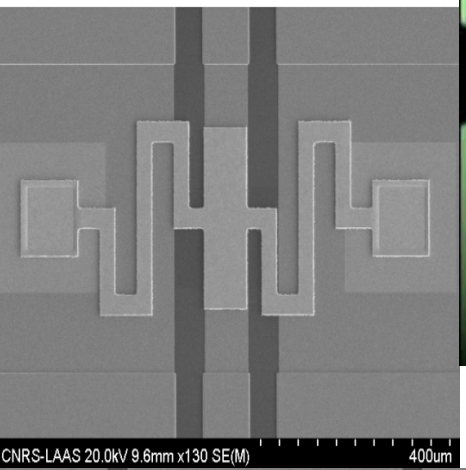


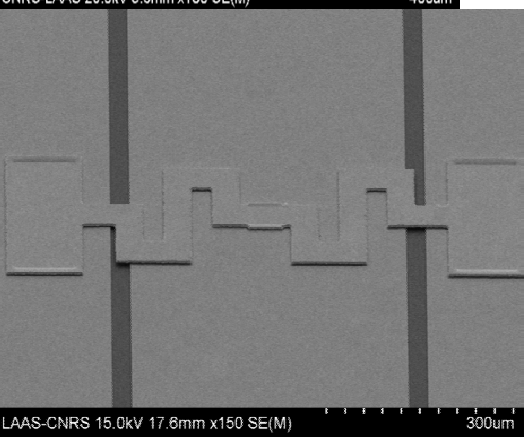
Biotinylated bacteria deposition on a microstructured surface with epoxide-streptavidin functionalized patterns

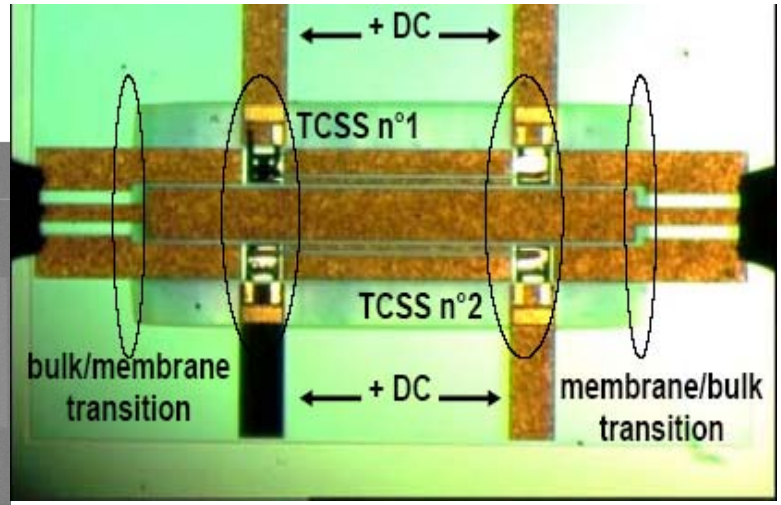


RF MEMS/NEMS
Bulk Silicon Micromachining

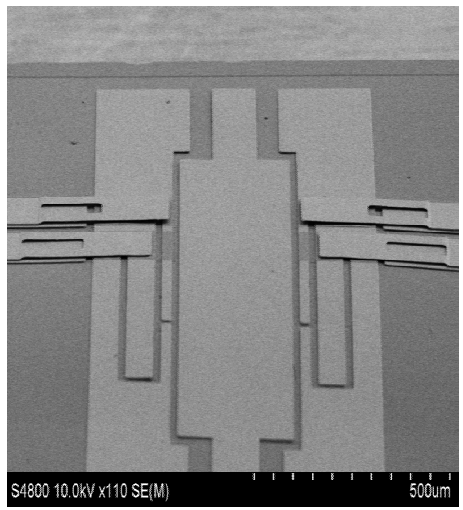
capacitive switch



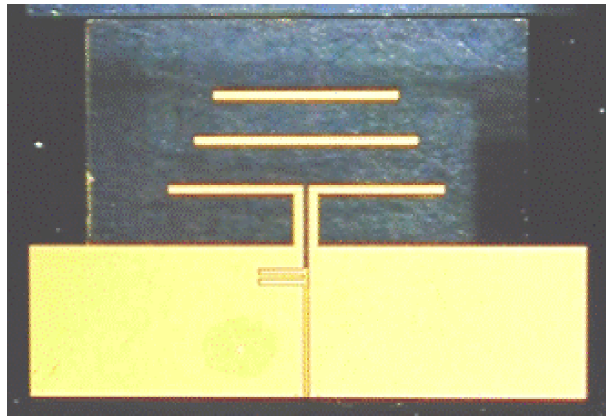




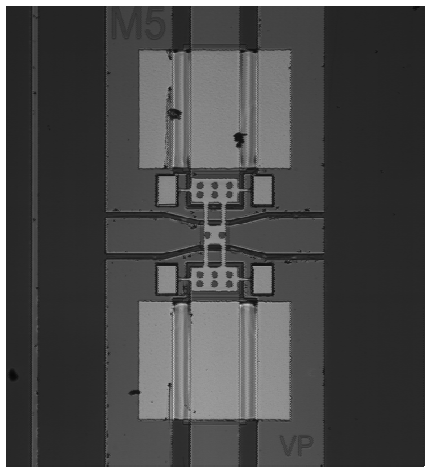
60 GHz Suspended filter



tunable filter @60 Ghz

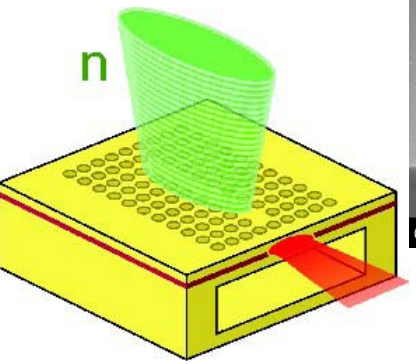


77 Ghz suspended yagi antenna

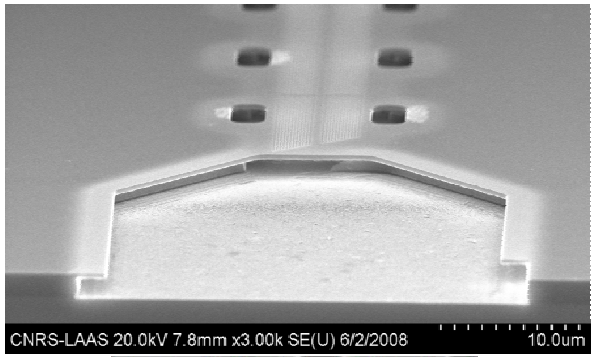


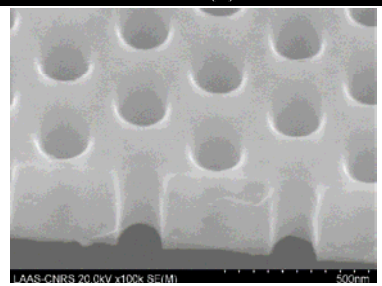
Tunable MEMS 10 GHz to 94 GHz

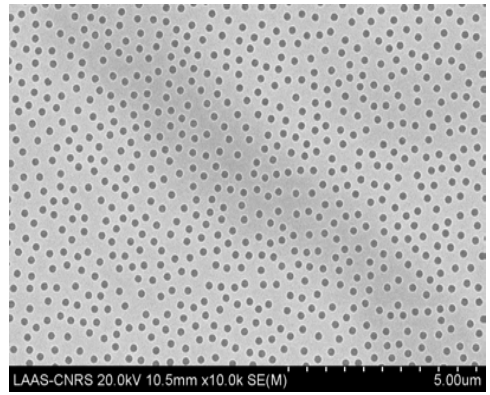
Photonic Optical Sources



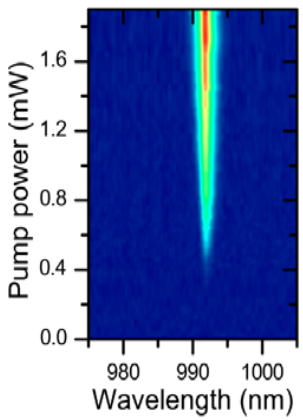
Cristal photonic laser

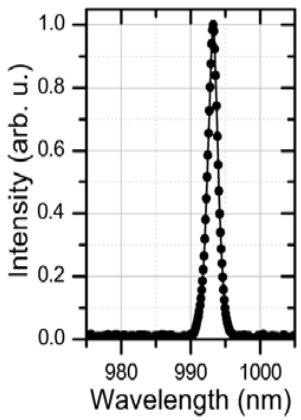


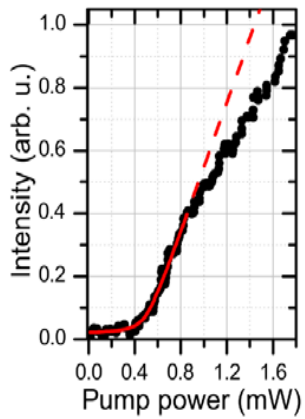


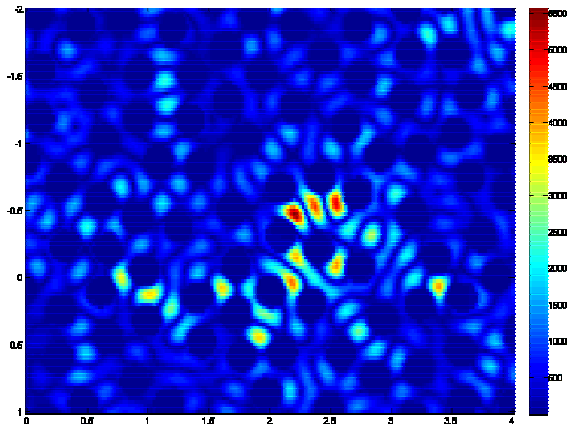


(In)GaAs/AlGaAs menbrane

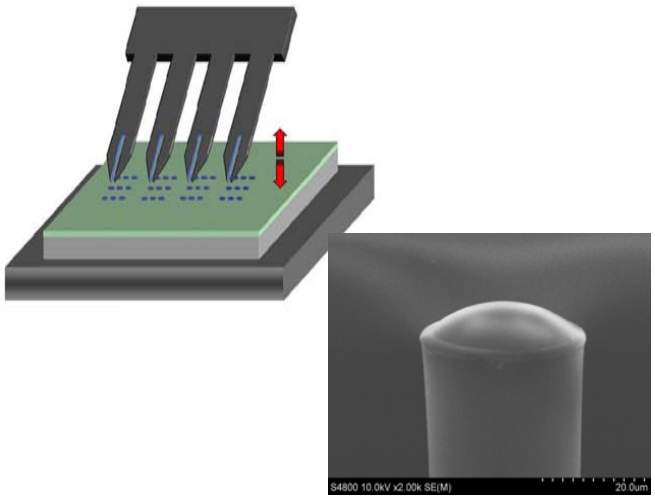




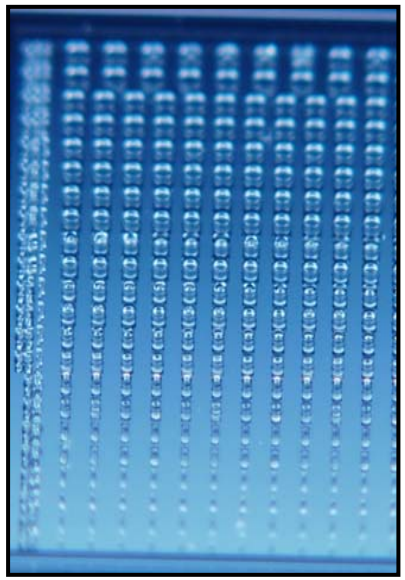




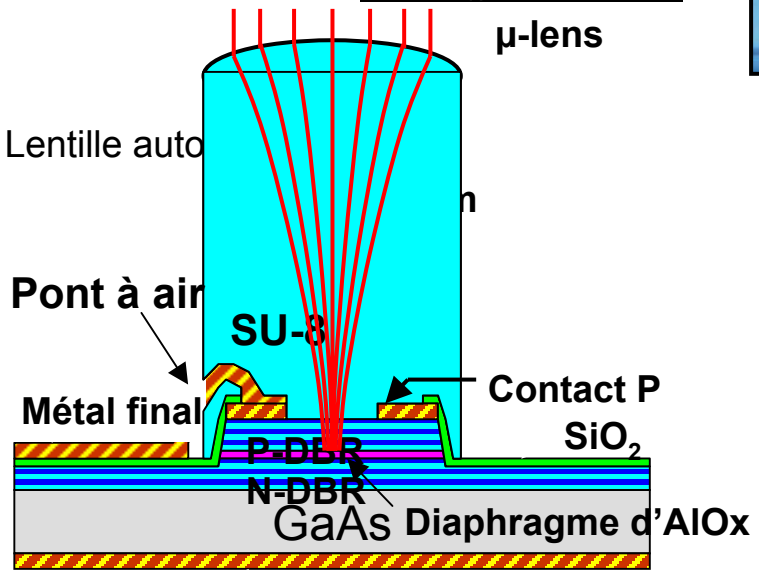
Photonic
Integrated optics

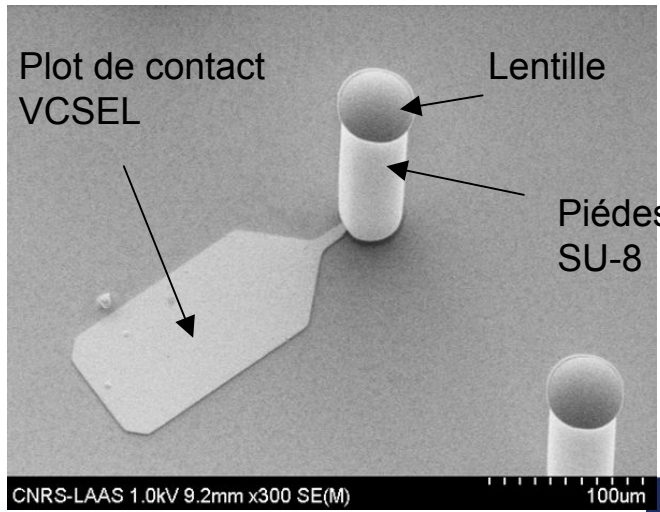


µ-lens

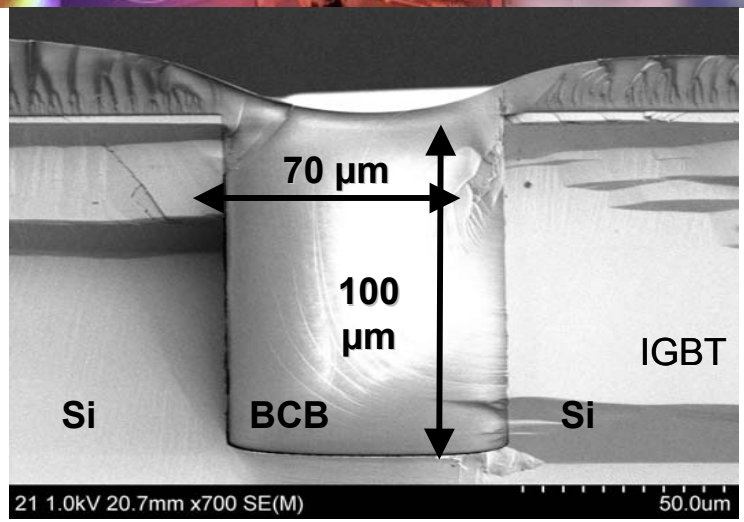


Integrated VCSELs

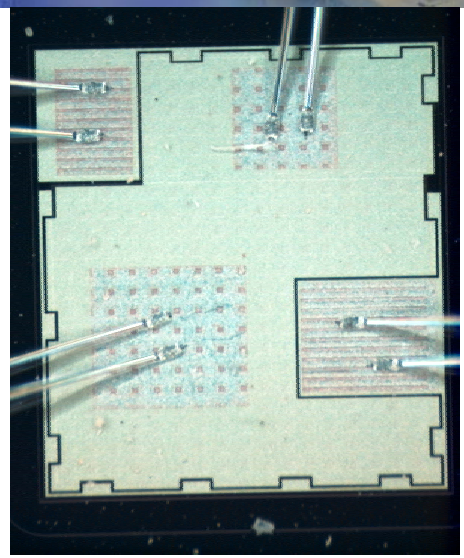




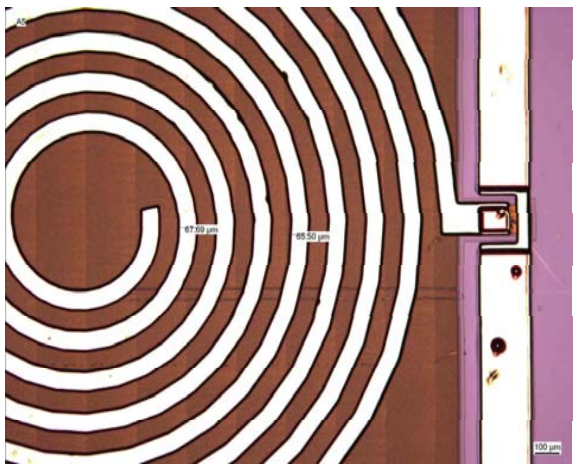
Energy Conversion



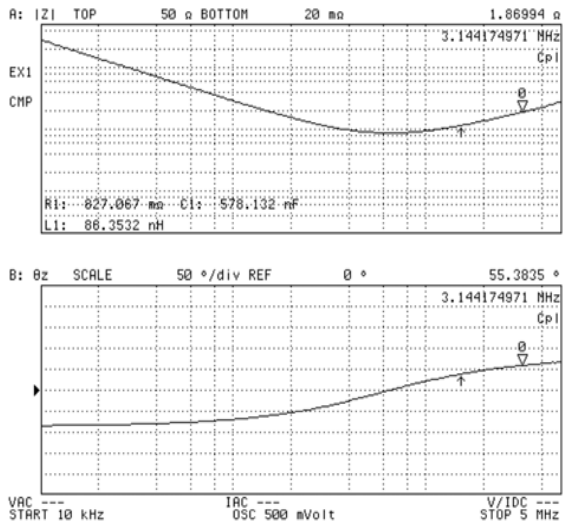
Superjonction Power MOSFET



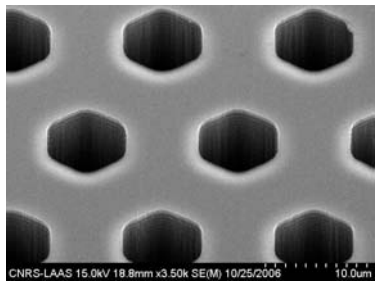
IGBTlow losses



LC filter

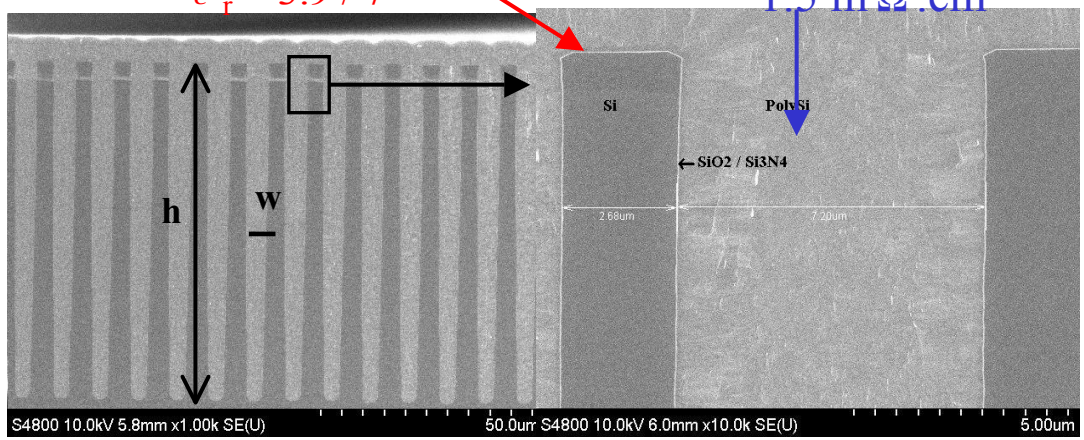


Energy
3D Capacitors



SiO_2 (5 nm) / Si_3N_4 (20 nm)
ε_r = 3.9 / 7

In-situ boron doped polySi
1.5 m Ω .cm

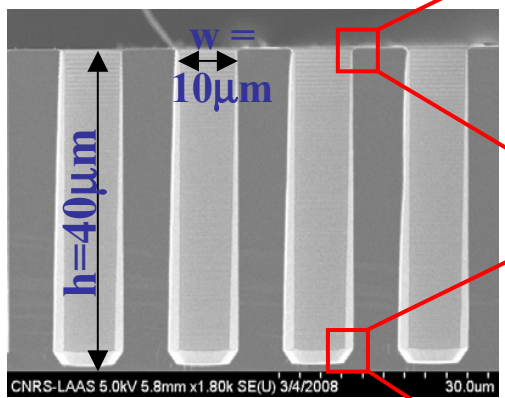


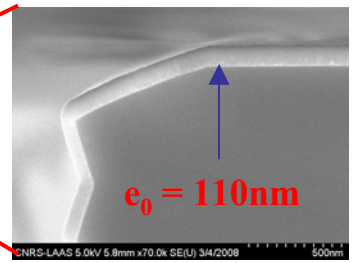
– 60 nF/mm²

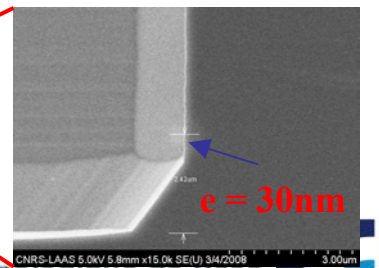
– f_{max} = 1MHz

- ZrO_2 MOCVD deposition

– ε_r = 20-40

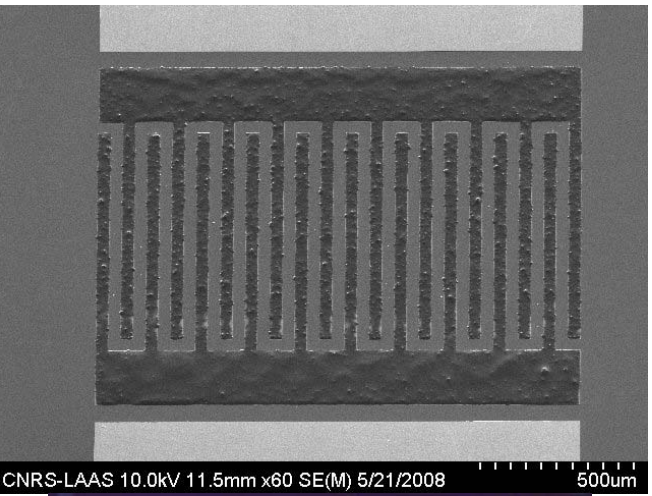


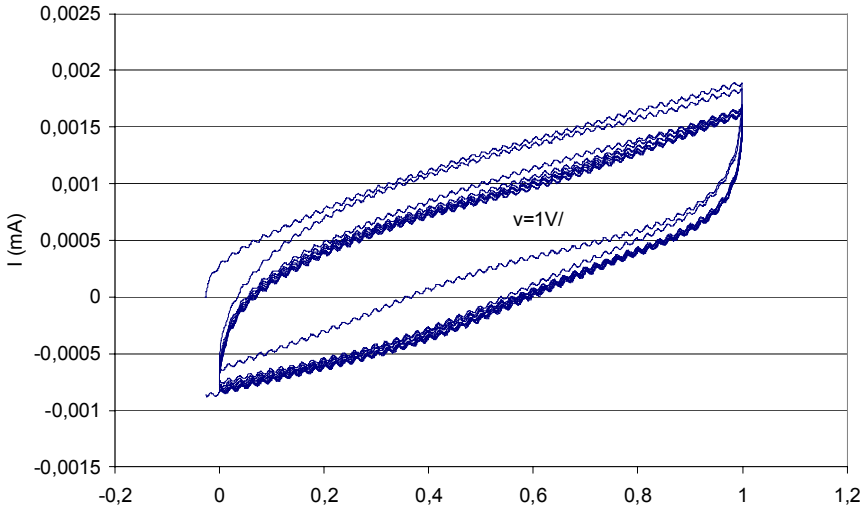


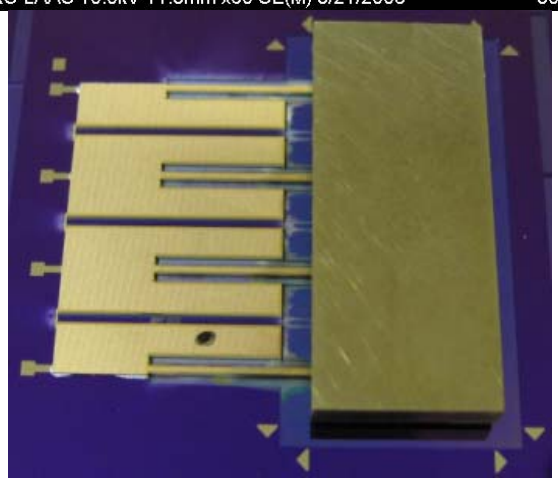


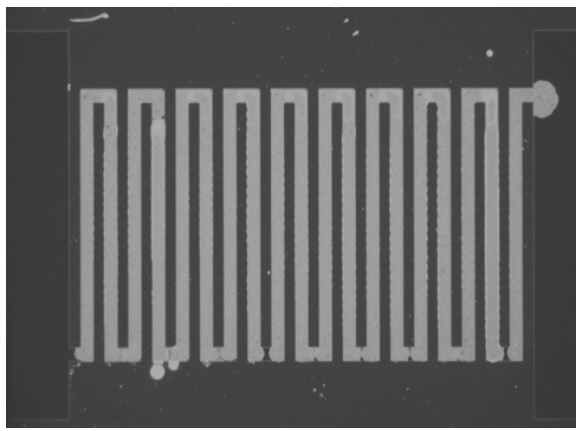
Energy
Harvesting ,storage, protection

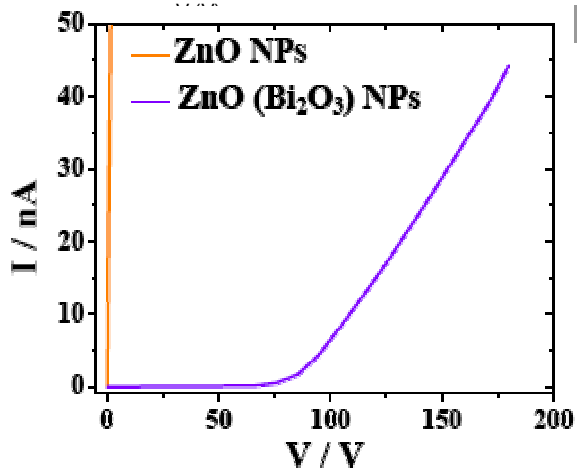
Supercapitors: inkjet deposition









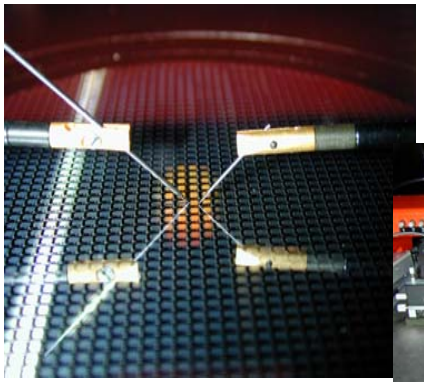


MEMs harvesting

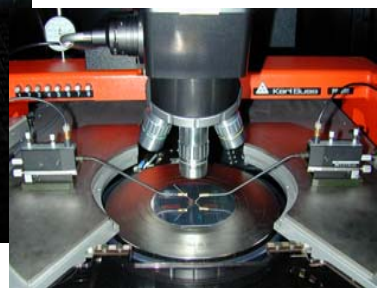
Zno Varistance

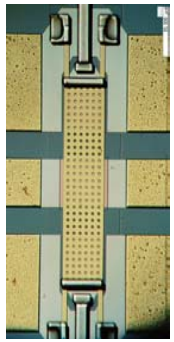
Characterization facilities

☞ **Tests and characterizations of materials, components and systems:**



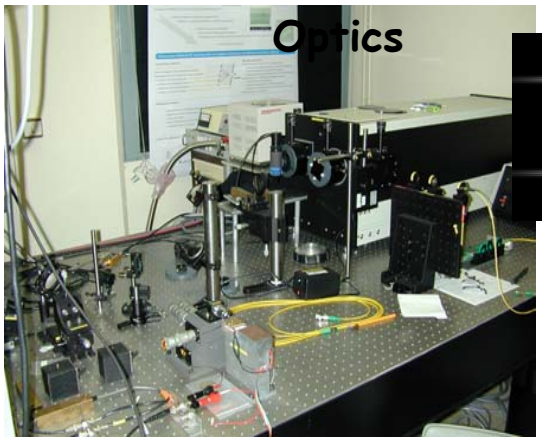
- Electronics



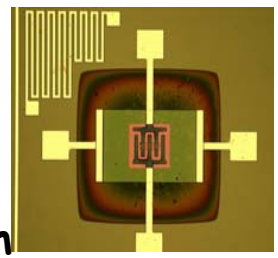


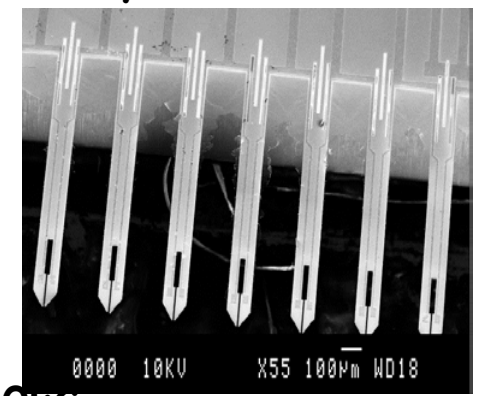
- Ultra High Frequency

- Optics



- Micro & Nano Systems





- Surface : 500m
- 55 test benches
- 5 engineers and technicians
- Annual operational budget ~80k€