EUROPEAN ASSOCIATED LABORATORY "SMART MEMS/NEMS for advanced communications and sensing" LEA SMARTMEMS

Common European Laboratory LAAS-IMT-Forth

Prof. Robert Plana; Dr. Alexandru Takacs

OUTLINE

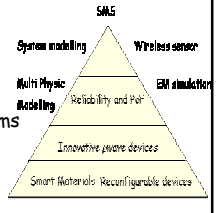
- **Partners**
- **Scientific objectives and main strategics topics**
- **Organization**
- **Facilities & equipments**
- **Scientific projects**

Partners:

- **Laboratory of MIcro et Nanosystèmes pour la Communication (MINC) of the Laboratoire d'Analyse et d'Architecture des Systèmes (LAAS), UPR 8001 CNRS, directed by Dr Raja Chatila**
- **Microelectronics Research Group of the IESL-FORTH, directed by Prof. Kostas Fotakis**
- **Laboratory of Micromachined Structures, Microwave Circuits and Devices (RF MEMS) of the IMT, directed by Prof. Dan Dascalu**

Scientific objectives and main strategic topics

- Smart materials (ferroelectric, ferromagnetic, metamaterial, piezoelectric..)
- Reconfigurable devices and circuits
- Innovative devices
- RF MEMS reliability
- Multi-physic modelling
- Electromagnetic simulation of complex systems
- System modelling
- Wireless sensor network



ORGANIZATION

Steering Committee:

- **representatives of CNRS:**
- Director of the Institute of Information and Engineering Sciences and Technologies (INST2I);
- Director of LAAS;
- **representative of IMT:**
- General Manager
- **representative of FORTH:**
- President of the board of Directors
- IESL Director

Co-directors

- Prof. Robert PLANA for CNRS, France,
- Dr. Alexandru MÜLLER. for IMT, Romania,
- Dr. Georges KONSTANTINIDIS, for FORTH

Chairperson:

as of January, 1st 2009, is the CNRS INST2I Director: PROF. PIERRE GUILLON
→ President for the first mandate

Composition of the Scientific Expert Panel as of January, 1st 2009

INSTITUTION/LABORAT	NAME	CITY, COUNTRY
EPFL	Adrian Ionescu	Lausanne, Switzerland
IEMN	Lionel Buchaillot	Lille France
FEMTO	Michel De la Bachellerie	Besançon, France
IMEC	Harrie Tilmans	Leuven, Belgium
Univ Perugia	Roberto Sorrentino	Perugia, Italy

Composition of the LEA SMARTMEMS Steering Committee as of January, 1st 2009

INSTITUTION	NAME, TITLE, FUNCTION	CITY, COUNTRY
CNRS	**-PROF PIERRE GUILLON,** DIRECTOR OF INST2I **-DR RAJA CHATILA**, DIRECTOR OF LAAS	**France**
IMT	**-PROF DAN DASCALU,** GENERAL MANAGER OF IMT	**BUCAREST, ROMANIA**
FORTH	**-PROF. ALKIVIADES PAYIATAKIS,** PRESIDENT OF THE BOARD OF DIRECTORS	**HERAKLION GREECE**

ORGANIZATION

The Parties appoint one of the Steering Committee members as Chairperson in rotation for two years in order to preside the Steering Committee.

Personnel assigned to contribute to the LEA shall remain administratively dependent on their original institution and unit and shall carry out its work under the administrative supervision of their unit director.

LEA members shall have access to the facilities and/or equipment throughout the term of this Agreement for purposes of carrying out the research project.

INSTITUTION	LABORATORY	PERSONNEL	TITLE
CNRS	LAAS-CNRS	*Permanent*	
		Robert Plana	Prof
		Patrick Pons	CR
		Hervé Aubert	Prof
		Daniela Dragomirescu	MCF
		Temporary	Post doc
		Puyal Vincent	IR Contractuel
		Fabio Coccetti	IR Contractuel
		Mahmoud Al Ahmad	PHD Student
		Usama Zaghloul	PhD Student
		Jason Puiran	PhD Student
		Ahmed Ali	PhD Student
		Mohammed Lamhamdi	PhD Student
		Mai Vu	PhD Student
		Mehdi Jatlaoui	PhD Student
		Fabienne Pennec	Post doc
		Sébastien Pacchini	Phd Student
		Hicham Youssef	PhD Student
		Adrien Broue	Post doc
		Alex Takacs	
IMT Bucharest	RF MEMS Lab	*Permanent*	
		Alexandru Muller	DR
		Dan Neculoiu	Dr
		Gheorghe	Dr
		Ioan Sajin	DR
		Dan Vasilache	Phys
		Andrei Muller	PhD student
		Alina Cismaru	Dr
		Anton Comel	Dr

INSTITUTION	LABORATORY	PERSONNEL	TITLE
FORTH	IMRG-IESL-FORTH	*Permanent*	
		George Konstantinidis	Dr
		Elias Aperathitis	DR
		Kostas Zekentes	Dr
		Zacharias Chatzopoulos	Prof
		Eleftherios Iliopoulos	Prof.
		Alexandros Georgakilas	Prof.
		Nikos Pelekanos	Prof
		Katerina Tsagaraki (mrs)	Research assistant (RA)
		Maria Androulidaki (mrs)	Research assistant (RA)
		Michalis Stendourakis	Technical assistant (TA)
		Temporary	
		Thanasis Kostopoulos	RA
		Antonis Stavrinidis	RA
		George Deligeorgis	RA
		Alexandros Pantazis	PhD students
		Raluca Buiculescou	PhD student

FACILITIES AND EQUIPMENTS OF THE LEA SMARTMEMS

CNRS-LAAS (Toulouse, France):
Clean room facilities (1500m2)
Characterization platform (material and microwave)
Design platform
Design tools

Forth (Heraklion, Greece):
Clean room facilities including nanolithography and material characterization

IMT (Bucharest, Romania):
Clean room facilities including nano lithography and material characterization
Microwave characterization
Design tools

Project N° 1 : Smart materials

Lead : IESL
Partners : LAAS-IMT

In this project, it aimed essentially to explore the potentialities of ferroelectric, ferromagnetic and piezoelectric material to develop new microwave devices. In this context, it will be **investigated the properties of GaN membrane to fabricate high quality factor resonator using bulk acoustic wave mode**. This has been already demonstrated by the groups involved in Smartmems laboratory and the very attractive capabilities exhibited have opened new ways for future to have thinner membrane to reach higher frequency range for instance. The second type of material that will be investigated within **this project deals with original ink based on carbon nanotubes nanoparticules and Fe_3O_4 nanoparticules**. It is tackled to explore the properties offered by this type of nano-ink for future devices. Finally, the third type of material that will be investigated deals with **PZT materials to form new type of actuator featuring very low actuation voltage**. Finally the last type of material that will be explore deals with BST based materials where it will be investigated how to minimize the insertion loss and how to optimize the quality factor up to millimeterwave.

Project N° 2: Reconfigurable devices from millimeterwave to THz

Lead : LAAS
Partners : IMT, IESL

*This is the original project on which the collaboration has been established and this project will continue by exploring new architectures to develop reconfigurable millimeterwave devices and systems using the RF MEMS technologies. Two different technologies will be investigated. The first one developed at LAAS will consist in developing **RF MEMS devices on silicon** and the second one **to move to higher frequency will be developed at IESL on GaAs substrate**. It has to be outlined that in order to improve the insertion loss and the isolation, it will be developed RF MEMS on air suspended that is very original. This project will of course cover a large part of **research concerning modelling and library development** in order to foresee more complex devices involving a large number of RF MEMS devices. Finally, in order to reach more complex architectures, it will be explored the possibility to **couple RF MEMS technology with ferroelectric materials** in order to extend the reconfigurability capability of the future architectures.*

Project N°3: Nanoscale Microwave

Lead : IMT
Partner : IESL, LAAS

This project proposes to **address the RF, microwave and millimeterwave capabilities exhibited by nanotechnologies**. The first type of material enabler deals with carbon nanotube where attractive microwave properties have been already demonstrated by numerous teams and we have been among the first outlining the fantastic capabilities exhibited by carbon nanotubes to form innovative devices like new switch, new resonator or new sensor. This project will continue under the SmartMEMS laboratory by exploring the **capabilities of CNT to fabricated new RF miniaturized power meter** and new alternative for **energy scavenger using the giant Seebeck coefficient exhibited by CNT**. It has to be outlined that we have recently demonstrated these two concepts theoretically and we have to validate by fabricating devices that will be the objectives tackled during the two next years. It has to be outlined that last april, we have submitted an European proposal to the JTI CATRENE in this field. Additionally, we are **investigating the microwave properties of nano-ink through ink jet process to develop the next generation of RFID on paper, textile, anything**. We have already demonstrated very exciting behaviour of such ink that could create a complete new paradigm for future RF circuits as we have demonstrated that it could be possible to have tunable resistance, capacitance and inductor with very simply architecture. We have to confirm these preliminary results and to stabilized the ink jet process. Here again, the first results are very promising. The last part of this project deals with the **investigation of the microwave properties of grapheme sheet** as this material has demonstrated very attractive properties in term of carrier mobility and loss and we are thinking to propose alternative integrated circuit using this technology

Project N° 4 : Wireless sensor network

Lead : LAAS
Partners : IESL, IMT

This project has been initiated by LAAS four years ago and part of it will be transferred within the SMARTMEMS laboratory as using the smart materials results and the capabilities of nanotechnologies for future sensors, it will be investigated to research new generation of wireless sensors. For instance, the vision that is chosen here deals with the **demonstration of sensor (pressure, chemical, strain gauge…) based on microwave, millimeterwave resonance** that has demonstrated enhanced sensitivity. It will be continued to explore this concept by **developing new type of sensors** and by using an **original reader concept using the radar cross section** value exhibited by the sensor. Using this concept, it will be possible to abandon sensors purely passive and to read their values only by measuring the radar signature of the objects. This concept has been validated by LAAS and will be used in this project to anticipate the future generation of wireless sensor network featuring advanced autonomy.

Project N°5 : Simulation and Modelling of complex architectures

Lead : LAAS
Partner : IMT

This project will concern the **simulation techniques that will have to be developed to cover the vision of exploring the electromagnetic engineering from material to system level**. The scientific issues are the **multi-physic behaviour** that will have to be taken into account.

Project N°6 : Reliability from material to system

Lead : LAAS
Partner : IMT, IESL

This project like the previous one is very transverse as introducing new materials, new technologies will probably be associated with unknown failure mechanisms and it is important to assess them. For instance, an intensive effort is allocated to understand the **metal-metal and metal-dielectric contact into micro and nano-assembling**. The investigations are carried out under a theoretical point of view and an experimental point of view. For instance, the contact is investigated at the nanoscale level using the roughness measurements and trying to understand the physic of contact and the associated failure mechanisms. We have developed very original multi-physic model and original experimental test set to explore the physic of failure at a nanoscale level. The model developed will introduced into the device architecture and latter on at a system architecture in order to be able to **predict the life time of a wireless sensor network and to introduce enough intelligence to reconfigure the network to extend the life time.**

LAAS Facilities

Micro, Nano technology facilities

Support endogenous and exogenous research projects

Facilities

- 1500 m² clean room
  - Specialized areas
- From class 10 000 up to class 100
  - Upgradeable (Filter Fan Units)
- Adaptative structure
  - 4 level architecture

Technical staff (TEAM Service)

- 26 engineers, assistants and technicians
- Specialized by technological fields
  - 12 technical zones
  - 1 zone support
- Processes supervision, running, and enhancement

Investments

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

Micro, Nano technology facilities

From Mask fabrication

Optical photolithography

Electronic lithography

Thin film deposition

Electrochemical deposition

Metallization

M.B.E

Wet Etching

Plasma Etching

Chemistry

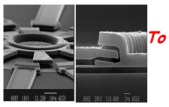
Ion implantation

Packaging

To Characterization

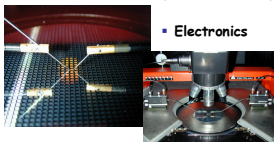
Infrastructure and support

- 20 M€ equipment total value
- Flexibility
  - Manual / Semiautomatic /Automatic equipments
- Si and III-V technologies
- 4" Si wafers (upgradeable to 6 ")
- Developments in substitution technologies

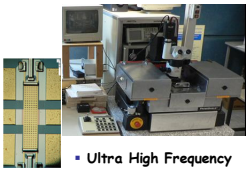


Characterization facilities

☞ Tests and characterizations of materials, components and systems:

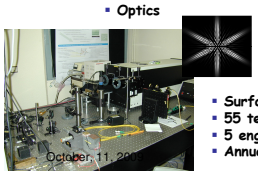


▪ Electronics

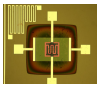


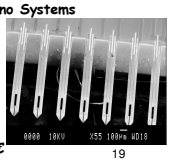
▪ Ultra High Frequency

▪ Optics



▪ Micro & Nano Systems





- Surface : 500m²
- 55 test benches
- 5 engineers and technicians
- Annual operational budget ~80k€