Thesis title : **Energy storage microdevices on chip.**

	Director	Co-director
Nale	Magali Brunet	Patrice Simon
ED	GEET	Sciences de la Matière
Laboratory	LAAS	CIRIMAT
	CNRS	Université Paul Sabatier

Contexte :
The fast expansion in the use of mobile electronic equipment as well as the increasing needs for wireless sensor networks raise the problem of energy storage: how to power multiple systems without increasing connections or battery size? Power densities of standard micro-batteries are quite low. Supercapacitors the other hand, have a huge power density and a long life cycle and are in this sense environmentally friendly. There is a need for miniaturization of storage devices for MEMS applications or for energy harvesting systems. **The thesis project deals with the development of high energy density storage microdevices. It is necessary then to combine two areas: material science/ electrochemistry and micro and nanotechnologies.**
In general, devices realized thanks to micro and nanotechnologies present a very high surface to volume ratio. In the case of storage devices, this high ratio will allow the development of new types of devices between batteries and supercapacitors. This properties improvement is seen in particular when using the nanostructuration of electrodes. The thesis is part of an exchange program (PUF) with the University of Drexel, Prof. Yury Gogotsi whose team develops nanostructured carbon-based materials.
A major scientific breakthrough concerning new electrochemical phenomena at micro and nanoscale is expected.

Program :
First, the major challenge will be the technology. Various micro and nano-technological processes will be developed (screen printing, inkjet printing, lithography). Storage microdevices are made of two electrodes separated by an electrolyte. Synthesis of these active electrodes will be achieved either by nanostructuration of the substrate (Si, SiC), either by the deposition of nanoporous materials. The principal aspect will be the synthesis of the electrodes and the integration of the complete micro-device. Then, the physico-chemical characterization of the electrode materials together with the electrochemical properties of the device will allow the optimization of the process and the understanding of the effect of miniaturization on the performances.
One of the direct applications is the storage of the energy harvested by microsystems. A prototype should be realized at the end of the thesis, that presents a complete integrated system with the energy harvester, the storage and the associated electronics.

Teams :
The thesis will be supervised by Magali Brunet in LAAS and by Patrice Simon and Pierre-Louis Taberna in CIRIMAT.
LAAS has a 1500m² clean room that contains all the micro-and nano-technologies necessary for the realization of micro and nano-sytems. In particular for this project, screen printing, inkjet equipments are available as well as electrochemical deposition techniques, chemical posts for the material synthesis. Some equipment for physico-chemical characterization of materials (SEM, EDX, AFM, FTIR, ellipsometry) is available as well as equipments for the electrical characterization of micro-devices.

The group of Prof. Simon at CIRIMAT has a wide expertise on storage devices (batteries, supercapacitors). In the laboratory, equipments of electrochemical characterization are available. Several chemical posts and a glove box necessary for the realization of prototypes (cell-type) are present.