# 12 months Post-Doctoral position

## NanoSmArc Project

Nano Smart Architected Materials for multi-functional new applications

**Subjects:** Ferroelectric systems (organic and inorganic), piezoelectric coefficients, local polarisation dynamics, nucleation and growing of ferroelectric domains.

**Researchers involved:** S. Mercone (MC-HDR, FINANO, LSPM), A. Garcia-Sanchez (I.E. Responsible of the SPM, LSPM), F. Mammeri (MC-HDR, Nanomatériaux, ITODYS), C. Ben Osman (Post-Doc ANR, Nanomatériaux, ITODYS) and S. Ammar-Merah (PR, Nanomatériaux, ITODYS).

**"Critical switching dynamics and non-epitaxial effect on the nano-scale domain polarization in ferroelectric (organic and inorganic) thin films"**

A post-doctoral grant for an experimental physicist in material science is open within the framework of a project dealing with new smart architectures based on the combination of flexible ferroelectrics and nano-magnets.

## A/ Brief description of the project and postdoctoral position objectives

### 1/ Context

In the growing field of the new smart technology the use of multi-phased artificial materials is drastically growing. Inside this frame, nano-composite structures artificially combining together a polymer ferroelectric phase with a magnetic nanoscaled one is attracting a lot of attention due to possible applications in magneto-electric flexible devices. The idea of switching the magnetization of the nano-objects interfaced with the ferroelectric organic phase, by applying a low voltage to this latter, is extremely interesting for new low-energy-coast magnetic memories. It is evident that in this field, the comprehension and control of the piezoelectric properties in the organic material and their efficient coupling at the interface with the magnetostrictive phase, is absolutely mandatory.

The discovery of the ferroelectricity in thin films based on the electro-active PVDF polymer has opened up new opportunities for polymer applications in nanotechnology and microelectronics [1-2]. In the case of the thin films of copolymer P(VDF-TrFE), a clear polarization switching with low coercive voltage (around 1 V) has been observed, thus showing a good compatibility with the modern microelectronic devices [2-3]. Also a good stability in time of local polarized domains has been already reported by nanoscale piezoelectric measurements [4]. This latter work demonstrates that both the polarization value and its stability on time are comparable with the ones obtained in the standard inorganic PZT ultrathin films. Nevertheless, if on the one hand the switching dynamics of the local domains growth (nucleation and expansion) in epitaxial PZT films is now well understood, there is still luck of studies in literature concerning this dynamic process in the polymer films where different mechanisms compared to the inorganic epitaxial films are expected. The nucleation and expansion behavior of the polarized nanoscale domain under the application of the intense electric field applied by the AFM-Tip, is a crucial study for future nano-patterned magneto-electric devices based on this polymer.


[1] Bune A.V. *et al.*, Nature (Lond.) **391**, 874 (1998).
[2] Ducharme S. *et al.*, Phys. Rev. Lett. **84**, 175 (2000).
[3] Qu H. *et al.*, Appl. Phys. Lett. **82**, 4322 (2003).
[4] Bystrov V.S. *et al.*, J. Phys. D: Appl. Phys. **40**, 4571-4577 (2007).

### 2/ Goals

The aim of the post-doctoral project is to study into details the piezoelectric properties of the PVDF polymer by using a local microscopy probe (PFM). The local piezoelectric response of the polymer will be compared to the one of the standard inorganic PZT films (epitaxial and polycrystalline). The scanning probe microscopy will be developed and adapted to the needs of both the organic and inorganic surface by using well-suited tips and allowing external voltage sources. The NanoSmArc project will fully sponsor the equipment development of the PFM.

The objective of this post-doctoral fellowship is twice:

i) To measure the polarization effect of the tip bias value (DC) and also the writing time (pulse range between 1Hz and 100KHz) in order to understand the dynamics of the switching process in the ferroelectric domains and their propagation,

ii) To study the critical regime in which the switching is not always successful and thus depends on the local heterogeneous distribution of the activation/pinning energy for polarization reversal (a huge statistics based on several numbers of polarized dots and local cycles will be studied over the polymer surface).

The project will be divide into two steps: the first one will be to understand mechanisms observed on the pure PVDF film by comparing our results to the one obtained on the inorganic PZT films (several thicknesses will be studied in both cases) and the second step will be to verify that the previous behaviors are still observable in the case of the nano-composite materials. The piezoelectric properties of nano-composite films made by Cobalt-based nanoparticles embedded into the polymer matrix will be studied in this purpose.

## B/ Chased Profile

The candidate must possess strong background in material physics (Ferroelectricity and polarization) with experience in nanostructures or thin films by means of local physical probes. Extra skills in organic ferroelectrics would be greatly appreciated.

## C/ LABEX SEAM teams involved

Several Team belonging from 5 different laboratories of the Labex SEAM consortium are involved into NanoSmArc Project. Concerning the goals foreseen in the frame of the 12 months position, the post-doctoral researcher will develop the project through a narrow collaboration between the FINANO Team (LPEM-UP13), the Nanomatériaux Team (ITODYS-UP7) and the PON (LPL-UP13), three laboratories localized in the Parisian area.

## D/ Financial Support ad expected collaborations

Labex SEAM (French Consortium of CNRS Laboratories) foresees the financial support for the 12-month position in the frame of the national structuring Project NanoSmArc. Collaboration with national (S. Cherifi, UPMC (Strasbourg)) and international (Prof. Kleeman, (Angewandte Physik, Universität Duisburg-Essen, Germany)) collaborators will be strengthened during the fellowship.

**Starting period**: The position must start before December 2015, for 12 months. The salary will be of 45.000 euros for the 12 months (see the CNRS table).

Applicants should submit their CV with a publication list, a brief description of past research experience and accomplishments and some references if possible to:

Dr. Silvana MERCONE, silvana.mercone@univ-paris13.fr