MASTER DE PHYSIQUE ET APPLICATIONS - 2ème année
Spécialité Sciences des Matériaux et Nano-objets
International Nanomat Master Program

Internship proposal 2010-2011

Laboratory : Institut des Nano Sciences de Paris

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Artificial Multiferroic Thin Films

Scientific project : Multiferroics are materials that are both ferroelectric and magnetic in the same phase. These two properties may be independent of each other or (more interestingly) be coupled. Very few multiferroics exist in nature and their synthesis in the form of ultra-thin layers is thoroughly searched for. They promise new device applications, in particular in the field of non volatile memories, where the possibility of manipulating a magnetic sate by an electric field (instead of by a magnetic field) is of major current interest. Such alternative seems feasible with multiferroics, using an electric-field control of the ferroelectricity and magneto-electric coupling. The manifestation of this coupling is at the heart of this project.

The strategy for engineering magnetoelectric effects is to use epitaxial thin-film (thickness ~ 1-20 nm) heterostructures, typically a two-phase system (ferroelectric phase and ferromagnetic phase). Coupling may arise at the interface between the two materials (electronic mechanism) or be mediated by the strain induced by the substrate.

In a first step, we will concentrate on the ferroelectric properties of thin layers of $BaTiO_3$, grown on different substrates. The growth will be achieved at the CEA-Saclay using molecular beam epitaxy, assisted by atomic oxygen plasma. The strain as well as the stoichiometry in the layers may markedly enhance or reduce the ferroelectricity. The ferroelectric parameters (remanent polarization, magnitude of the electric field for switching of the polarization, reversible or irreversible behavior, transition temperature) will be analyzed at the INSP using a dedicated set-up. Other analytical tools will be used to characterize the films : X-ray diffraction, medium energy ion scattering, electron microscopy,...

In a second step, a ferromagnetic film M will be grown on top of $BaTiO_3$. The analysis of the magnetization of M, as a function of the electrical polarization of $BaTiO_3$, will be undertaken using different techniques: SQUID magnetometry, ferromagnetic resonance, atomic force microscopy…

Techniques in use : See above

Applicant skills : motivation and multidisciplinarity

Granted internship : yes (417 € / month)
C'nano IdF laboratory (France only) : yes
Possibility for a thesis : yes (type of grant : not yet defined)