Cotutelle PhD thesis in the frame of ANR VOLCONANO (2019-2022)

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Hybrid Multiferroïc Nanostructures (0D/2D) under External Stimuli

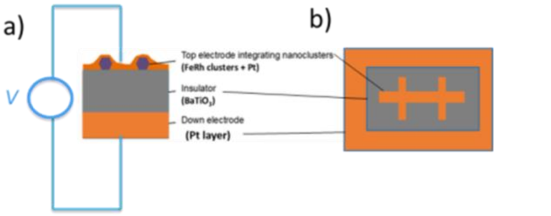

Schéma du Dispositif Multiferroïque en vue latérale (a) et de dessus (b)

Controlling nanomagnetism by means of an electric field is a key issue for the future development of low-power spintronic devices. In this project, we propose to tune in real time the magnetic reversal assisted by electric field of well-defined nanoparticles prepared by Low Energy Clusters beam Deposition (LECBD) at the PLYRA[1] platform. In order to separate finite size effect, epitaxial strain and charge accumulation in a polarizable micro-device, FeRh nanomagnets will be deposited and studied on different piezo and ferroelectric (FE) systems as $BaTiO_3$ (BTO) monocrystal and epitaxially grown $PbZr_{0.2}Ti_{0.8}O_3$ films, then coating by top and bottom metallic electrodes to pattern the multiferroïc nanostructures by using the technological Nanolyon[2] platform.

Description of the work:

In this context, near equiatomic composition, the CsCl-like B2 chemically ordered FeRh alloy which presents a metamagnetic transition from a low temperature antiferromagnetic order to a high temperature ferromagnetic order just above room temperature, is a very good candidate for assessing magnetic control through external stimuli [3, 4]. The multiferroïc hybrid system proposed in the frame of the ANR VOLCONANO (VOLtage COntrol of NANOmagnet), is based on electric interfacial control of magnetic order in FeRh clusters prepared by LECBD deposited on FE substrates.

In this PhD thesis (2019-2022) financed by ANR VOLCONANO, the doctoral student will explore the finite size effect in multiferroic heterostructure at the ultimate nanoscale, by deposition of monodomain FeRh nanomagnets in the 2-8 nm diameter range grown on ferroelectric crystals of different natures and orientations in order to adjust separatly ferroelectric polarization, surface chemistry and strain on magneto-electric responses in such original capacitive device. By associating both co-supervisors Lyon teams expertises, in advanced synthesis and characterization of magnetic nanoparticles (iLM)[3] and of ferroelectric maters (INL)[4], the aim is to develop a multiferroïc hybrid heterostructures with particular interest for future (nano)microdevices due to the non-volatility of the information which can be stored in nanomagnets with proper anisotropy and the low consumption associated to voltage control. Complementary grazing X-ray diffraction under synchrotron facilities will be performed to study the crystal structure and epitaxial relationships at the interface between mass-selected FeRh nanocrystal on different FE substrates. Applying an electrical voltage between the two metallic electrodes creates an electrical field, which would gives rise to the polarization of the FE substrate and consequently to the modification of the magnetic order in FeRh nanoparticles by interfacial magnetoelectric coupling. The induced modifications under external voltage in the electronic structure of different components will be studied by *Operando* magneto-optical measurements of X-ray magnetic circular and linear dichroism with DEIMOS-SOLEIL partner.

The candidate must possess a Master in condensed mater physics, electronic/electromagnetic systems or materials sciences. Knowledges of nano-micro fabrication and characterization, magnetism and/or ferroelectricity would be appreciated as well.

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[1] Plateforme Lyonnaise de Recheche sur les agrégats de l'iLM

[2] Plateforme technologique Nanolyon de l'INL

[3] "Low Temperature FM in chemically ordered FeRh Nanocrystals" Hillion PRL 110, 087207 (2013) doi.org/10.1103/PhysRevLett.110.087207

[4] "Electric-field control of magnetic order above room temperature". Cherifi et al. Nature Mater. 13, 345 (2014) doi.org/10.1038/nmat3870

Equipes de recherche : "Nanostructures Magnétiques" ***iLM*** / "Dispositifs Electroniques" ***INL***
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