INTERNSHIP PROPOSAL

Laboratory name: Laboratoire Albert Fert
CNRS identification code: UMR137
Internship director'surname: Manuel Bibes
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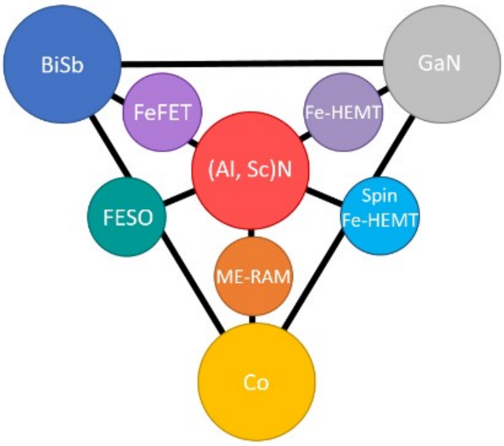
Internship location: Thales Research and Technology France, Palaiseau

Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: PEPR Spin

Ferroelectric nitrides for ultralow power spintronics

Spintronics is increasingly recognized as a solution for reducing the energy consumption of electronic components. However, a major hurdle lies in reducing the energy required to switch the magnetization of a ferromagnetic material, which currently relies on current injection, resulting in Joule-effect energy loss. Controlling magnetism with electric fields via magnetoelectric coupling (ME) could solve this problem. However, despite decades of research, results have been modest, preventing significant advances towards technological applications. For example, the most widespread approach relies on multiferroic materials, which are very rare at room temperature and not very compatible with CMOS integration. We propose a new approach to magnetoelectric coupling based on the use of **ferroelectric materials from the wurtzite-structured nitride III family**. These materials, whose ferroelectric nature was only discovered in 2019, have exceptional ferroelectric properties and can be processed on large wafers (300 mm) under conditions that allow their integration into CMOS. In addition, another approach to control spin information by ferroelectricity relies on the coupling of ferroelectrics with spin-orbit materials, and to harness spin-charge conversion thanks to the inverse Rashba-Edelstein effect. The ambition of the project is therefore (i) to explore new magnetoelectric coupling approaches using ferroelectric nitrides, capable of 180-degree magnetization switching and, ultimately, to develop a **CMOS-compatible ME-RAM**; (ii) to develop **ferroelectric spin-orbitronic** devices **(FESO)** for in-memory computing, based on ferroelectric nitrides and the topological insulator BiSb, for **very low-power** logic applications ; (iii) generate two-dimensional ferroelectric electron gases (2DEG) with tunable Rashba spin-orbit coupling and high mobility at room temperature based on AlScN/GaN stacks (**FE-HEMT** ferroelectric high electron mobility transistor).



During the internship, which will be followed by a thesis, both already funded, the candidate will develop AlScN-type ferroelectric materials in the laboratory. This will involve sputtering growth, structural characterization and measurements of their ferroelectric properties. He/she will then couple them with magnetic materials, also grown by sputtering, to study magnetoelectric coupling (magneto-optical measurements under magnetic and electric fields), as well as with the topological insulator BiSb to advance towards the ferroelectric control of spin-charge interconversion and FESO components.

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES Soft Matter and Biological Physics: YES
Quantum Physics: YES Theoretical Physics: YES