Thesis topic: Integration of new materials with strong spin-orbit coupling (van der Waals tellurides) for SOT-MRAM memories

The new concepts offered by "spinorbitronics" make it possible to envisage more frugal electronics. In particular, for writing a magnetic memory (MRAM), a new concept of magnetization reversal by a spin-orbit couple is emerging. Its principle permits a significant decrease in memory writing energy and enhanced endurance. Its operation is based on the conversion of a charge current in a material with a strong spin-orbit coupling into a spin current that is absorbed by the adjacent magnetic layer to be reversed (and which stores the 0 or 1 information). The higher the charge-spin conversion efficiency, the lower the current to be applied to reverse the magnetization, thus reducing energy consumption.

The objective of the thesis project is to maximize this conversion by developing and implementing new materials, the 3D topological insulators (TI). Indeed, it has been demonstrated recently that the charge-spin conversion was very strong in these materials thanks to the strong spin-orbit coupling and the existence of topological surface states in which it is possible to produce a strong spin accumulation thanks to an electric current. In this context, LETI is interested in the growth by sputtering of this type of materials on large surfaces. These are specifically bismuth and antimony tellurides ($Bi_{2-x}Sb_xTe_3$). In parallel, SPINTEC is actively involved in the study of spin-orbit torque, with an extensive expertise in deposition and control of ferromagnetic layers, as well as measurement of spin-orbit torques that cause magnetization reversal. The aim of this thesis project is therefore to combine LETI's know-how on TI growth and SPINTEC's expertise on ferromagnetic materials and spin-orbit torques. A thesis is currently underway at LETI on the development of $Bi_{2-x}Sb_xTe_3$ films on an industrial sputtering growth equipment. The goal of the proposed thesis project is to combine different x compositions of the $Bi_{2-x}Sb_xTe_3$ alloy with various FM ferromagnetic materials (CoFeB, CoFe, Co, Fe) to optimize these TI/FM couples and thus qualify these materials for their use in MRAM.

The PhD student will have to work in close collaboration with the LETI and SPINTEC teams in order to identify the best protective material to transport the TI samples "in the air" from the LETI sputtering tool to the growth tool of SPINTEC where the magnetic materials will be deposited. A surface preparation protocol must be put in place in order to remove the protective layer and recover the pristine surface of the TI essential to ensure a high quality interface with the magnetic layer. The chemical and structural characterization of the materials and stacks will be carried out at SPINTEC, at LETI or at the PFNC (NanoCharacterizations Platform) at CEA Grenoble. The PhD student will carry out the characterizations himself when possible. Experiments on large instruments (ESRF,..) could be considered as needed. The PhD student will also have to train in nanofabrication techniques at the PTA (Upstream Technology Platform) for the realization of the test devices to measure spin-orbit couples (SPINTEC). Different types of analysis can be carried out according to the observed behaviors; from the most conventional analysis measuring the amplitude and the direction of the torque to the most advanced evaluation of the magnetization switching mechanisms in the tunnel junction to the dynamic measurements of the magnetization.

The expected profile for the candidates is a Master 2 in condensed matter physics, or nanophysics with an obvious taste for experimentation and teamwork.

Applicants can send their CV, cover letter, and recommendation letters to berangere.hyot@cea.fr, pierre.noe@cea.fr, kevin.garello@cea.fr, matthieu.jamet@cea.fr or alain.marty@cea.fr.