Stage N° : 9

Contact

Olivier KLEIN
olivier.klein@cea.fr
Tel: 0438785802

Ursula EBELS
ursula.ebels@cea.fr
Tel: 0438785344

Title

Magnetic tunnel junction as nanosensor to detect propagating spin waves in insulating YIG

Summary

This project proposes to explore an alternative technology based on magnetic insulating magnonic materials to be used in **microwave analog front-end technology** that has a critical role in the emission/reception chain of **wireless telecommunication.** Existing technologies make use of parallel channels combining Low Noise Amplifiers (LNA) with thin-film surface/bulk acoustic resonators, which work on the interconversion of the electromagnetic signal into a slow propagating acoustic wave traveling in a compact delay line. Magnonic materials are here a timely replacement to the acoustic analogue, since the acoustic attenuation increases rapidly above a couple of GHz, and will be limiting in future technologies that foresee a shift of the carrier frequency towards tens of GHz and higher. This project proposes to use the propagation of **spin-waves** (SWs) or their quanta **magnons** to perform delay line functions, since they are expected to be more efficient loss-wise and are easily tunable over a wide frequency range by simply varying the strength of an external (global or local) magnetic field. This is a substantial asset since tuning the frequency in the microwave range does not generally come easily. Here $Y_3Fe_5O_{12}$ / **Yttrium Iron Garnet** (YIG) stands as the best material to propagate SWs [01]. The idea is to open a new era of miniature YIG-based **microwave analog front-end** through our unique ability to fabricate high quality YIG ultra-thin films, to nanostructure them using standard nano-lithography techniques and potentially to integrate them with other spintronics technologies. This project focuses on the latter aspect, by exploring the **integration of Magnetic Tunnel Junctions** (MTJ) with YIG. Such integration will provide innovative solutions to **inter-convert** the spin waves propagating in thin films into large electric signals at high gain. The two key advantages are i) the reduced size of MTJs provides near field solutions for sensing magnons, with the benefit of optimizing the coupling to the propagating SW and ii) biasing the MTJ will result in large output voltages, thus providing a large gain due to the large magneto-resistance ratios, without the need of integrating a local amplifier.

This internship will be carried out in collaboration with the University of Brest, who provides the YIG films,the CEA-Saclay who provides the MTJ materials and the platform of nanofabrication in Grenoble. The student will characterize the hybrid YIG magnonic / MTJ devices using electrical characterization techniques that will provide a novel technique for characterization of propagating spin waves. Once the technique is established this will be applied for the study of specific aspects of the non-linear dynamics of propagating spin waves.

Requested skills

M2 level, sound knowledge of solid state physics and/or Nanophysics and Nanosciences

Possibility to follow with a PhD: Yes