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Institut d'Electronique, de Microélectronique et de Nanotechnologie
UMR CNRS 8520

# Master and Engineer Internship: 2018-2019

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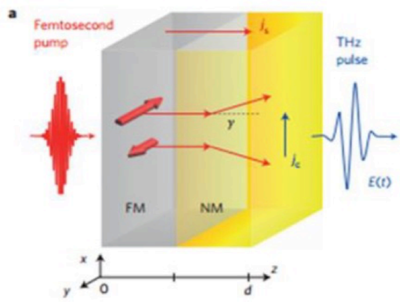
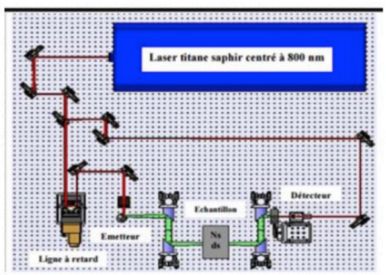
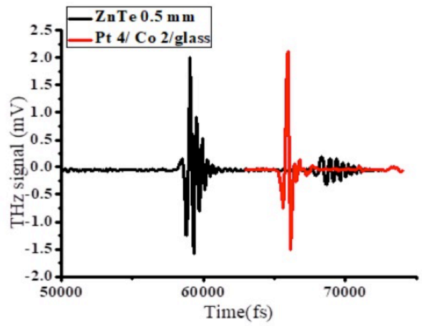
Research group : THz Photonics / AIMAN-FILMS

## Title: Active control of Spinorbitronic THz emitters based on inverse Spin Hall effect mediated spin-to-charge conversion.

Abstract: In spintronic based devices the information is coded onto the spin state of electrons. Having spin-polarized currents on a sub-ps time scale could potentially pave the way to THz speed spin electronics. This would allow a new realm for fast electronics circuits. A crucial element in this context is the availability of a physical mechanism allowing to process these ultrafast spin currents. The typical spin-to-charge conversion techniques that are used for this purpose must be able to follow THz bandwidths. Just over two years ago an innovative technique was proposed to observe these fast spin currents. By exciting electrons in a stack of 3d ferromagnetic (Co,Fe, …) and heavy nonmagnetic 5d metal (Pt, Ta, ...) layers using a femtosecond laser a spin-polarized current is created, because in the FM layer the mobility of spin-up (majority) electrons is significantly higher than that of spin-down (minority) electrons. Due to the high spin-orbit coupling in the heavy NM layer, spin–orbit interaction deflects spin-up and spin-down electrons in opposite directions and transforms the spin current js into an ultrafast transverse charge current jc= γjs, leading to the emission of a THz electromagnetic transient wave. Measuring this THz emission using THz spectroscopic techniques, leads to a contactless way of measuring the fs SSC signal. This allows not only insight into the microscopic physical mechanisms of ultrafast spin transport but also opens up a new technology for broadband pulsed and CW THz emitters.




In IEMN two research groups (THz Photonics and AIMAN) are collaborating to improve the functionalities of such demonstrated spintronic THz emitters. We are looking into the use of more sophisticated alloys and multilayers for the FM layer, in order to tune injected spin direction before its conversion. By engineering these layers their magnetization can be actively controlled and therefore also the amplitude and/or polarization of the THz emission. By combining this with fast magnetostrictive effects this could even lead to GHz modulated THz sources. In the framework of this internship, the successful candidate will actively contribute to the development of these novel emitters by participating in their growth by sputter deposition and assisting with their characterization on an advanced THz time-domain spectroscopic bench. An important part of the work will consist of adapting this time domain setup to include active control of the magnetic FM spin emission layer. If successful these demonstrations might lead to a number of scientific journal publications. The potential candidate will show sufficient background in photonics and solid state physics. Experience with magnetism is a plus. This internship might be extended into a doctoral study.

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