PhD Fellowship
Novel rapid continuous-wave THz sources exploiting broadband inverse spin Hall effect emitters

Context: The FET OPEN project s-NEBULA (a FR-DE-SE-CZ partnership led by THALES) explores a novel approach to THz generation exploiting ultrafast spin-orbit interaction (SO) at the interface of magnetic/ non-magnetic metallic thin films. The inverse spin Hall effect (ISHE) creates a net charge current when a spin-polarized current is injected into a heavy 5d metal that exhibits strong SO coupling. Using fs laser pulses shone on e.g. a Co/Pt stack, a spin current pulse is generated resulting in a ISHE-mediated ultrafast net charge pulse in the Pt layer (~100fs) emitting in the THz frequency range[1]. The advantage of such a spintronic emitter is multifold. Besides being compact and operated at room-temperature (RT), as it exploits the ultrafast electron relaxation times in metals and is not hindered by phonon absorption, it can be ultrabroadband and potentially polarization tunable by controlling magnetization in the ferromagnetic layer. Presently, there isn't a single solid-state THz emitter that is capable of delivering such a performance. ***This PhD project will explore the possibility of obtaining a tunable spintronic RT continuous-wave (CW) emission of THz radiation by photomixing two intense laser lines on a FM/NM multilayer.*** Up till now only pulsed THz spintronic emitters have been demonstrated.

Description of work: The PhD candidate will be involved in demonstrating the possibility of creating continuous-wave THz emission using spintronic effects. Such a demonstration would be a world first. In a second step it will be explored how the polarization of the CW signal can be rapidly modulated by reorienting the magnetization direction in the ferromagnetic layers using rapid magnetoelastic effects (coupling magnetization to strain or acoustic waves). Within the framework the PhD candidate will be involved in and leading some of the steps of the research tasks : from numerical modeling of the optical excitation of the spin currents, over the microfabrication of the metallic multilayers, to magnetic, optical, and ultrafast optoelectronic spintronic characterization. The candidate will play an active role in developing the new experimental bench for this project. He/She will also be fully involved with the ins and outs of the EU project and as such be a part of a top-tier research consortium and getting hands-on experience with challenges of meeting research milestones and deliverables, participating in consortium progress meetups and commission review meetings.

Profile of the candidate: The ideal candidate has a background in Solid-State Physics and/or Optoelectronics with a keen interest for characterization of ultrafast phenomena. A background in magnetotransport is a definite plus. The involved IEMN research groups (THz photonics and AIMAN-FILMS) have a longstanding research track record in the field of THz photonics and dynamic control of fast magnetic phenomena. Both research groups have an equipment portfolio allowing to immediately tackle all research challenges of the s-NEBULA project (fs lasers, photomixing setups, magnetometers, sputtering tools, THz detectors and spectroscopy, ...). IEMN itself boasts the presence of one the biggest academic clean rooms (1500m^2) in France offering all necessary technological fabrication infrastructures for micro- and nano-optoelectronics and micro- and nano-electromechanical systems.

Interested candidates are encouraged to submit their CV and motivation letter to both nicolas.tiercelin@iemn.fr and mathias.vanwolleghem@iemn.fr . More info on http://s-nebula.eu/

Start of the PhD contract September/October 2020.

1 Seifert, T., Jaiswal, S., Martens, U., Hannegan, J., Braun, L., Maldonado, P., ... Kampfrath, T. (2016). Efficient metallic spintronic emitters of ultrabroadband terahertz radiation. Nature Photonics, 10(7), 483–488. https://doi.org/10.1038/nphoton.2016.91