Université Lille Nord de France
Pôle de Recherche et d'Enseignement Supérieur

Ecole doctorale régionale Sciences Pour l'Ingénieur
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Titre Thèse	**Tip enhanced spintronic emitters for terahertz nanoscopy**	
(Co)-Directeur	**Mathias Vanwolleghem**	E-mail : mathias.vanwolleghem@univ-lille.fr
(Co)-Directeur		
(Co)-Encadrant		
Laboratoire	**IEMN, Université Lille**	Web :www.iemn.fr
Equipe	**THz Photonics**	Web :https://www.iemn.fr/la-recherche/les-groupes/photonique-thz
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Résumé du sujet :

The THz frequency range (0.1-20THz; 4-80meV) is home to many low-energy elementary excitations in condensed matter (phonons, magnons, plasmons, ...). Revealing their spectra at the nanoscale is currently a hot topic in spectroscopic micro- and nanoscopy, since it can bring insight of such low-energy THz dynamics in a contactless manner. Examples include plotting carrier dynamics in nanostructured semiconductor structures, mapping plasmon dynamics for 2D electronics [1], revealing phonon couplings and THz antiferromagnetic magnon excitations [2,3]. As such having a low-noise, high bandwidth spectroscopic source up to 20 THz, is crucial for developing the next-generation of electronic devices. High resolution nanoscale THz spectroscopy of carrier dynamics in spintronics and 2D materials in the wide frequency range from 1-20THz is currently the center of huge research attention. Attempts at tackling this challenge are seriously hampered by a lack of intense, sufficiently wideband THz sources and limited signal-to-noise ratio (SNR) detection.

This research project will bring a disruptive change for wideband THz nanospectroscopy. At its heart lies the nanoscale integration of an innovative spintronic THz emitter (STE). This includes three aspects:
1) an intrinsically spectrally ultra-broadband, intense, polarization-controllable and nanometric thin THz source, based on ultrafast spintronic effects.
2) enhancing its performance by coupling it to a metallic tip. This allows not only (a) by strong near-field confinement to increase the SNR and achieve nanoresolved near fields, but also (b) an innovative 3D THz nanospectroscopy with the emitter directly integrated on a AFM tip.
3) generate the very first hyperspectral images up to 15THz of two heavily pursued goals in nanoelectronics and spintronics: (i) THz plasmon dynamics in 2D materials and (ii) THz magnon-phonon coupling in multiferroic BiFeO 3 [4].

This PhD research will be conducted in the framework of a nationally research project (with partners at the LPENS and the Ecole Polytechnique) that is currently under evaluation for funding.

Dr. Mathias Vanwolleghem, mathias.vanwolleghem@univ-lille.fr

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