Thesis subject 2021

Laboratory: **Group of Electrical Engineering – Paris (GeePs)**; UMR CNRS 8507; CentraleSupélec; Materials Department: [http://mdmi.lgep.supelec.fr](http://mdmi.lgep.supelec.fr)

University: **Sorbonne Université**

Title of the thesis: **Innovative uncooled semiconductor detectors for fast terahertz imaging**

Thesis supervisor: **Prof. Annick Dégardin**

Email contact: [annick.degardin@sorbonne-universite.fr](mailto:annick.degardin@sorbonne-universite.fr)

Collaborations within the thesis: Centrale de technologie du Centre de nanosciences et de nanotechnologies (C2N, Palaiseau); Tonouchi Lab, Osaka University (Japan)

This subject can be published on the doctoral school’s web site: **Yes**

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**PhD Thesis Abstract**

Terahertz waves, which typically spans from 500 GHz to 5000 GHz (or 600 to 60 µm in wavelength), are rich in imaging applications. Indeed, many substances (water, gas, organic solids) selectively absorb THz waves. In addition, these waves can penetrate non-conductive materials (plastic, ceramic, paper, wood, fabric, etc.) while they are reflected by metal surfaces. Finally, unlike X-rays, THz waves are recognized as harmless to living tissue. Thus, THz waves are of interest for: the diagnosis of hot plasmas (renewable energies: controlled fusion); biomedical (as a tool to aid in the diagnosis of cancerous tumors); the industrial environment (quality control or sorting of waste).

At GeePs, we are developing, testing and modeling thermal detector arrays (sensors sensitive to the magnitude of the incident radiation). These detectors, which are uncooled, are made from thin films of an innovative oxide material (semiconducting Y-Ba-Cu-O). Near infrared (IR) tests (λ < 2 µm) show impressive performance in terms of response time (2-3 µs) as compared to uncooled detectors used in commercial thermal cameras (0.1-100 ms). To develop these detectors for longer wavelengths: THz waves (60-300 µm or f = 1-5 THz), each detector must be coupled to a planar metal micro-antenna. The two following main points will be dealt with in the thesis work:

a) **Physical properties of semiconducting oxide materials.** This will involve studying the properties (microstructure, DC and AC electrical transport) of other semiconducting oxides than Y-Ba-Cu-O in order to optimize the performance of detectors made with these new materials. It will also involve extracting, by UV photoelectron spectroscopy, the electronic affinity of the oxides and the work function of the contact metals to be optimally associated with these oxides. Finally, THz wave interaction with oxides will be studied by THz time domain pulsed spectroscopy (collab. with Osaka University) in order to understand carrier dynamics in these oxides and so optimize the design of the future sensing pixels.

b) **Design of antennas, device technology and validation.** Each pixel will be coupled to a planar micro-antenna to favour coupling between the pixel and THz incident radiation. As small 2D arrays of 2×2 pixels, then 8×8 pixels will be developed, thermal crosstalk between the pixels as well as electromagnetic crosstalk between the antennas of the array will be simulated. Large scale models of designed antennas will be fabricated and tested in anechoic chamber, and experimental results will be compared to simulation results. Technological process of small arrays will be performed using clean-rooms facilities at C2N. Operational tests in the THz range using quantum cascade lasers will be conducted in parallel to optimise various pixel parameters: sensitivity, noise level, bandwidth and crosstalk between pixels.

**Required education and skills:** Master of Science degree or equivalent degree in Photonics, Electronics, or Applied Physics. Excellent academic results are required.