Master and Engineer Internship: 2018-2019

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Title : Ultrafast photoconductors for optoelectronics-based detection of millimeter and submillimeter waves using 1550 nm-lasers.

The emergence of Ti:Sa mode-locked lasers emitting optical pulses at 800nm has enabled the development of THz spectroscopy systems based on ultrafast optoelectronics. These systems use photoconductors (PCs) working at 800nm as emitter and detector of THz electromagnetic waves. In both cases, the incident subpicosecond optical pulse generates in the photoconductor an ultrafast change of carrier density, whose rising time depends on the optical pulse duration whereas the decay time depends on the carrier lifetime in the photoconductive material. When a dc bias voltage is applied between the electrodes of the photoconductor, the carriers are accelerated by the static electric field, and an ultrafast current pulse is generated and can be radiated into free space by a THz antenna. In detection, the bias voltage is replaced by the incident THz waves collected by the antenna. A photocurrent is generated in the photoconductor only if both the carrier density transient and the THz wave are present at the same time. The receiving photoconductor acts as a photoswitch triggered by the optical pulses. The photocurrent flowing through it depends indeed on the product of the bias voltage and the incident optical power. This double dependence, not present in the photodiodes photocurrent-voltage characteristics, is essential to obtain an efficient photonics-based detection of RF/THz waves. In a lower frequency range, this has also been used to sample millimeter waves signals, first step of a photonics-based analog-to-digital conversion useful for detecting radar emission. In both cases, a high dark resistance (Roff) and a low photoresistance (Ron) are demanded to obtain a highly efficient detector of electromagnetic waves. Most of the THz PCs working at 800nm are based on low-temperature-grown GaAs (LT-GaAs) because of its suitable properties, after post-growth annealing, for ultrafast/THz optoelectronics such as high dark resistivity, ultra-short carrier lifetime and relatively high carrier Last years, researches have been focused on the development of efficient PCs working at 1.55 µm based on InGaAs grown on InP substrate in order to take advantage of the turn-key, reliable and low-cost 1.55-µm fiber-components. However, their performances are still far from those of the LT-GaAs photoconductors.

The goal of this internship is to study InGaAs-based ultrafast photoconductors using optical cavities in order to develop competitive ultrafast photoconductors operating at 1550 nm for the next generation THz spectroscopy systems and optoelectronic-based analog-to digital conversion system.

In a first time, the master student will perform the optical and electrical design of the ultrafast photoconductor and will study high-dark-resistance photoconductive materials based on InGaAs by using ionic implantation and/or by incorporating higher bandgap semiconductors.

In a second time, based on the results obtained during the first period, a photoconductor will be fabricated in the micro and nanotechnology fabrication facility and characterized in the characterization center.