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

MASTER INTERNSHIP POSITION

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Titre : Design of a THz optoelectronic heterodyne mixer

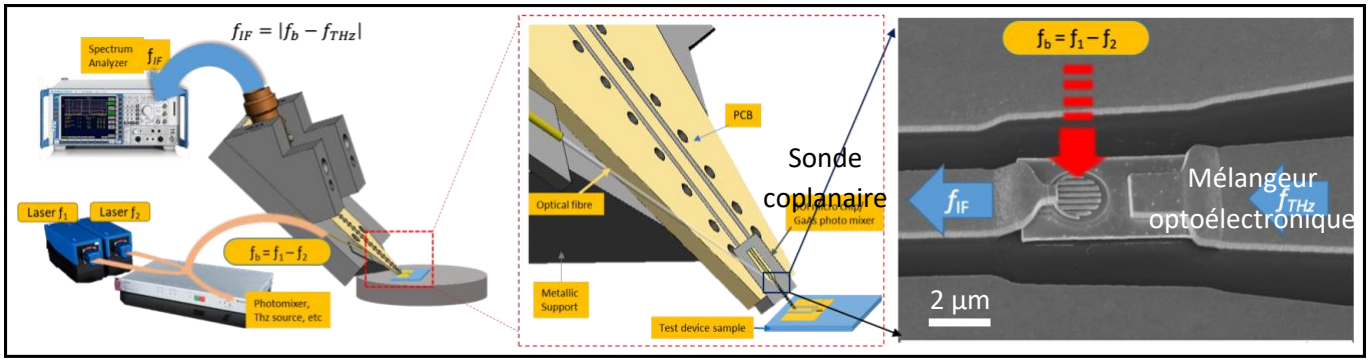

Figure 1 : Principle of optoelectronic mixing on a coplanar probe for broadband characterization of the dynamic electrical properties of THz components on a wafer. The frequency f_{THz} of the signal to be measured is down-converted to a lower intermediate frequency fIF, which can be analyzed by standard measuring equipment directly on the probe using the optoelectronic mixer, pumped by an optical beat frequency $f_b = f_{THz} \pm f_{IF}$.

Context : The increasing frequency requirements for the operation of electronic and photonic components in telecommunications necessitate the development of ultra-wideband characterization tools, covering a frequency range from tens of GHz to several hundred GHz, and even up to 1 THz. Today, standard characterization tools, such as spectrum analyzers and vector network analyzers based on traditional electronic technologies, are limited to frequencies below 100 GHz. To extend beyond this range, multiple costly extension modules are required, which only allow narrowband-to-narrowband analysis. A promising approach to developing ultra-wideband characterization tools is to use techniques from microwave and THz photonics, which allow high-frequency signals to be down-converted to baseband for analysis.

The THz Photonics team has been developing optoelectronic heterodyne mixers for the past decade, based on photoconductors in optical microcavities, achieving conversion losses of around 1% in the THz domain—only 10 times lower than electronic mixers. Today, it is conceivable to create a very wideband spectrum analyzer and/or vector network analyzer (0-1 THz) using these technologies, with measurement dynamics comparable to existing solutions.

This area of research is currently supported by the French National Research Agency (ANR) through a collaborative research project (PISA, PRCE 2023), bringing together IEMN, the FOTON Institute at the University of Rennes, and the company MC2 Technologies.

Tasks : The selected candidate will collaborate with a PhD student working on the project to design the first-generation circuit of an optoelectronic mixer integrated on a coplanar probe, enabling the characterization of 'on-wafer' electronic components up to 500 GHz (see operating principle in Figure 1). The design of the mixer will be carried out using ADS and CST Microwave software. It will require both linear and nonlinear modeling of the mixing circuit. Traditional solutions used in RF design, such as filtering, parallel configurations, etc., will be tested during this internship to evaluate the ultimate performance achievable with this technology.

Expected profile : For this internship focused on RF & THz design, we are looking for a student who has followed an academic path in Electrical Engineering or a related field with a strong background in RF/microwave or analog electronics and who is motivated by research in applied physics.

Career Opportunities offered by this internship : The intern can then continue with a PhD or move towards the RF & microwave components and systems industry, which is currently highly promising.

Note: TWO MONTHS DELAY BETWEEN APPLICATION AND INTERNSHIP STARTING (ZRR CLEARANCE DELAY)

Salary : ~600€/month. **Duration : between 4 and 6 months** **Starting date : Mars 2027**