THz coherent source based on light structuration using III-V semiconductor laser technology

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THz COHERENT SOURCE BASED ON LIGHT STRUCTURATION USING III-V SEMICONDUCTOR LASER TECHNOLOGY

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RÉSUMÉ

We have developed a continuous wave optically-pumped Vertical-External-Cavity Surface-Emitting Laser (VECSEL) emitting at 1064 nm. We will present THz emission thanks to beating of different modes where the frequencies difference is in THz regime using a plasmonic-electrodes photoconductive antennas (PCA) as a photomixer.

MOTS-CLEFS : *semiconductor ; bimodal laser ; photomixing ; photoconductive antenna ;*

1. INTRODUCTION

Electromagnetic waves in the THz band cover the range of frequencies from 100 GHz to 10 THz. Emissions in this frequencies band can pass through multiple materials without being attenuated or reflected, which is perfect for applications such as spectroscopy and telecommunication. The THz band could offer a seamless transition with high-speed fiber optic networks. Indeed, it has already been demonstrated that THz communications are superior to 80 Gbps [1]. However, the path to efficient industrial systems remains on fundamental and technological challenges, including limitations in emitters and detectors.

Our solution to develop a THz emitter is based on a bifrequency semiconductor VECSEL, which is known for its compactness, coherence, agility and low cost. It is possible to have a transverse degeneracy condition, where the coexistence of multiple transverse modes appears for the same parameters of the system. The simplest scenario is to have two different modes oscillating at two different frequencies f_1 and f_2, i.e. transverse modes [2]. Therefore, if these modes oscillate simultaneously, a THz wave can be generated thanks to a photomixing process, at frequency $\Delta f = |f_2 - f_1|$. Figure 1.a is a scheme of the optically-pumped VECSEL and shows how the excitation of the two modes is performed by centering the pump diode on an absorbing Cr mask to only excite the fundamental and a selected high-order mode thanks to the petal-shaped mask.

Photomoxing is a good solution to generate a tunable continuous THz wave at room temperature. Among possible photomixers, photoconductive antennas are composed of an ultrafast photoconductor connected to a terahertz antenna on a photo-absorbing semiconductor substrate. If two optical pump beams with the same power and a terahertz frequency difference are incident on the ultrafast photoconductor, it allows for the generation of a continuous THz radiation as illustrated in Figure 1.b. The applied bias voltage on the photoconductor and induced photocurrent proportional to the optical power drives the terahertz antenna and generates terahertz radiation at the offset frequency of the pump beams. The tunability of the THz wave depends only on the tunability of the optical beams. Despite the great potentials of photomixers for generating high terahertz radiation powers at high optical pump power levels,

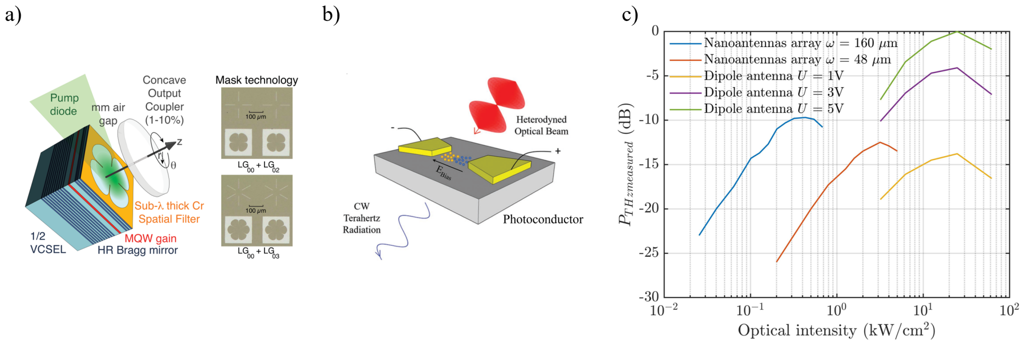

FIGURE 1 : a) Scheme of the VECSEL's setup, the gain medium is based on multiple quantum wells (QWs), which are optically pumped using a pump diode at the Brewster angle and the metallic masks used on the ½-VCSEL structure to excite two Laguerre-Gauss's modes. b) Schematic diagram and operation concept of photoconductive antennas photomixers illuminated under a heterodyned CW optical beam (picture taken from [6]). c) THz emitted power versus optical intensity using unbiased 0.5x0.5 mm^2 nanoantennas array with two different beam waist 160, 48 μm, a 1x20 μm^2 gap biased dipole antenna at 1, 3 and 5 V.

performance of existing photomixers is severely limited by poor quantum efficiency of their ultrafast photoconductors. The solution proposed to increase the quantum efficiency is to incorporate a plasmonic contact electrode configuration [3].

These antennas offer a promising alternative to UTC photodiodes. The integration of these plasmonic photoconductive antennas with VECSEL technology holds the potential to create a robust, coherent, tunable, and powerful THz emitter. We will present the state of the art of continuous-wave THz emission based on plasmonic-electrodes photo-conductive antennas, either biased [4] or unbiased [5], optically-pumped at the specific wavelength of 1064-nm, and discuss about the physical effects that limit the THz output power at this specific pumping wavelength as it is shown in figure 1.c.

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