THECAMAP: Terahertz Camera for medical Application

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***Abstract*— We are developing a THz Imager System to identify the tumors such as in vivo and in vitro detection. THECAMAP (TeraHErtz Camera for Medical Applications) system will design to allow a real time detection of the reflected THz radiation by the MUT (material under test) and to provide a high sensitivity and spatial resolution.**

I. Introduction And Background

THz wavelengths offer potential for imaging and spectroscopic medical applications because they are long enough to pass through many materials that are opaque in the visible spectrum but short enough to form sub-millimetre resolution images, are non-ionizing, are subject to far less scatter than visible or infrared wavelengths and large bio-molecules display distinct spectra in this range. At present the ability of terahertz (THz) pulse imaging to distinguish skin cancer from normal tissue, may be extended in diagnosis of several tumors and it represent one of the most interesting application in medicine field [1]. The tumor cells display different molecular and chemical characteristics respect to the normal cells. The tumor mass is differently organized in an imbricated vascularization and in a mass rich in water depending from the type of tumor. The wavelengths THz characteristics can be used in the tumor studies to develop the application of the THECAMAP in medical oncology. Different type of tumors could be detected using THz. Glioblastoma multiforme (GBM) is by far the most common and most malignant of the glial tumors in the brain. Glioblastoma is particularly rich in blood vessel and water. These characteristics render the tumor mass detectable to the THECAMAP in particular districts like cranium. Importantly, our THECAMAP system can be able also to evaluate anatomic differences in subcutaneous structures or in Non-Melanoma Skin Cancer (NMSC). NMSC is the most prevalent cancer in the light-skinned population. Noninvasive treatment is increasingly used for NMSC patients with superficial lesions: The application of THZ could be relevant to develop a noninvasive diagnostic tool. To assess the potential of THz in tumor diagnosis, we will develop experiments in mice.

Tumor cells lines derived from solid tumor with high level of angiogenesis, then with a diffuse vascularization; tumor cells lines with low vascularization and tumor cell lines not able to growth, used as control; will be subcutaneously injected in NOD/SCID mice. Three mice will be injected for both treated and control cells.After injection the mice will be followed in the first 21 days to detect differences by THECAMAP during the increase of tumor mass. At the end of experimental procedure the mice will be sacrificed, cancers will be removed and subjected to morphological and biochemical evaluations by immunohistochemistry and western blot analyses. A comparison and a relation between the mass of the tumor and the image detected with THECAMAP will be performed. The information resulting from this project will be utilize to evaluate, during surgeries, the mass limits of tumor to optimize the complete removal of the entire tumor mass.

II. Results

The system will include a closed cycle optical cryostat where both THz source and detector are located, compact optics capable of focusing at the diffraction limit, and a raster-scanning stage to collect the intensity reflected at specular angle from different points of the sample. The reflectivity of tissues of interest is expected to be below 10%, and the specularly reflected intensity will be further reduced by surface scattering, atmospheric absorption and tight focusing. A total power attenuation of 60 to 100 dB from source to detector is foreseen. Therefore, we selected a Quantum Cascade Laser (QCL) as a source capable of producing few milliWatts, and a low-noise superconducting bolometer as detector, with a dynamic range from picoWatts to nanoWatts, in order to detect strongly attenuated signals from a diffraction-limited focal size.

The QCL which we use is a 2.5 THz laser, derived from the 2.5 THz laser of [3], by modifying the upper state of the lasing transition to have an increased penetration in the preceding injector. In order to minimize current flow prior to alignment, the ground state of the injector has been pushed farther away from the active region to reduce parasitic scattering to the lower laser level. The upper laser level consists of a single isolated subband, whilst the bottom state lies at the top of a group of closely space subbands span an energy range of 12 meV. The structure grown by MBE consists of 110 period embedded in A3914 optical waveguide. At temperature T = 40 K, the output power of devices from sample A3914, driven with 200 ns current pulses at a duty cycle of 5% and at 8 K, is in excess of 20 mW, as measured with a thermopile detector.

The detector is a superconducting microbolometer coupled to a planar log-spiral antenna and operating in vacuum to about 4K [4]. The microbolometer consists of a narrow niobium air bridge, voltage biased to form in the middle of the suspended Nb stripe a resistive hotspot, whose volume is modulated by the incoming radiation [5]. The noise performances of this device have been measured by using a home made transimpedance amplifier operating at room temperature, resulting in a NEP of about $40fW/Hz^{1/2}$.

At first the MUT will mount on a x/y stepper and a dedicated electronics control circuitry masters each single devices, such as the motion of the stepper, the pulsed generator which feeds the QCL, the transimpedance amplifier which comes out the electric signals from the superconductive bolometer. The MUT is located at a distance of about 5cm from the cryostat optical window. Some optical. elements allowed both the collimation of the laser radiation (by elliptic polyethylene lens) to a spot of about 100μm on the

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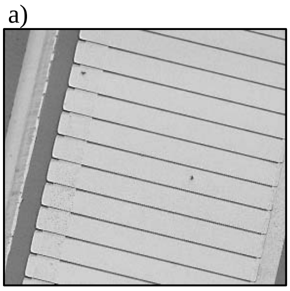
MUT surface, and the collection of the THz radiation from the MUT (by a parabolic mirror) to be fed to the detector.

a)



b)

Figures: a) detail of the 2.5THz QCL; b) detail of the superconductive bolometer

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