Pulsed Terahertz Imaging of Paraffin-Embedded Pancreatic Ductal Adenocarcinoma

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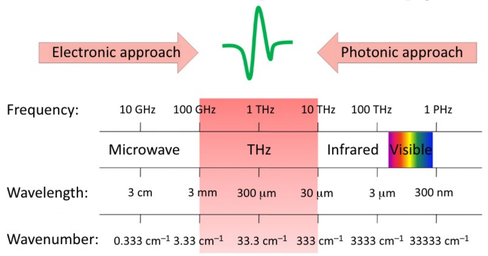
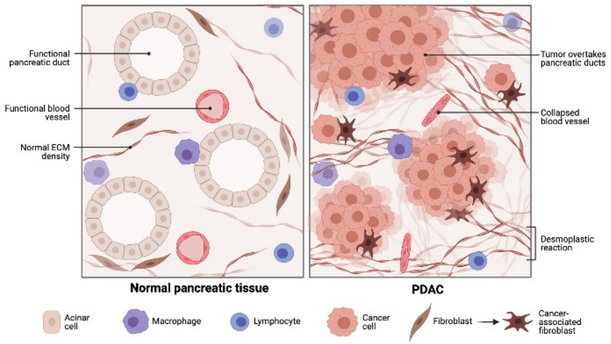
Terahertz Spectroscopy



- Terahertz (THz) region is known as the 'molecular fingerprint region' in the electromagnetic spectra [1].
- Pulsed THz Time Domain Spectroscopy (TDS) is a non-ionizing and non-destructive tool to probe a wide variety of materials with sub-millimeter resolution and high signal-to-noise ratio.

PDAC Microenvironment



We have conducted our current research to develop and investigate the viability of pulsed TDS imaging to study pancreatic ductal adenocarcinoma(PDAC), which is one of the most fatal malignancies.

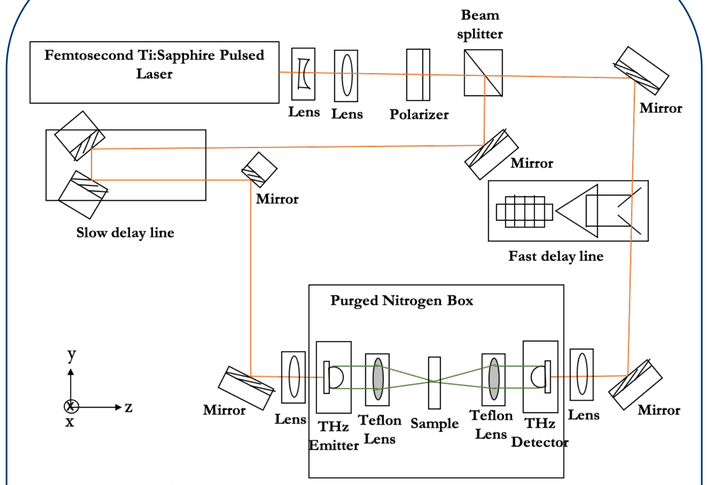
References

[1]. Yang, Xiang, et al. "Biomedical applications of terahertz spectroscopy and imaging." *Trends in biotechnology* 34.10 (2016): 810-824

[2]. T. C. Bowman et al., "Terahertz imaging of excised breast tumor tissue on paraffin sections." IEEE Trans. on Antennas and Propagation., vol 63.5, pp 2088-2097, 2015.

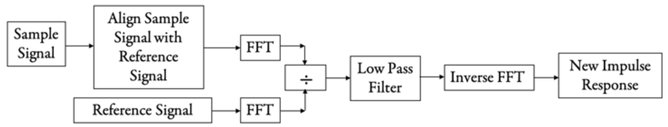
[3]. Chakraborty, Debamitra, et al. " Pulsed Terahertz Time-Domain Spectroscopy of Paraffin-Embedded Pancreatic Ductal Adenocarcinoma." *2021 46th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz)*. IEEE, 2021.

Experimental Set-up



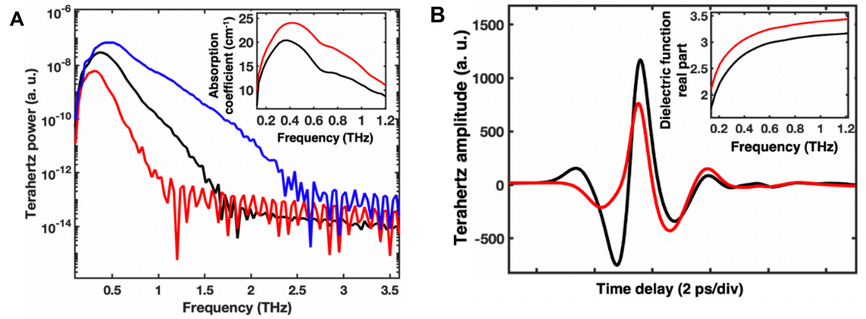
Pulsed TDS experimental set-up in transmission geometry with samples mounted on a motorized, computer-controlled x-y stage to perform raster scans. Low-temperature grown GaAs photoconductive antennae were used as both the THz emitter and detector.

Impulse Function Extraction

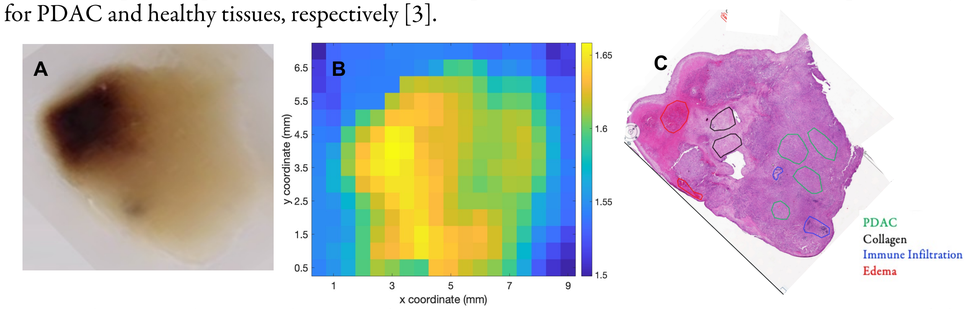


We studied paraffin embedded pancreatic murine tissue samples. Therefore, THz transients contain the contribution from both the tissue and the paraffin. We performed a deconvolution procedure to get tissue impulse response adopted from [2]. We used a THz transient transmitted through the paraffin only as a reference signal and digitally removed it from a sample signal (paraffin-embedded tissue section), getting, eventually, the tissue signal.

Results



THz characterization of healthy pancreas and PDAC tissues. THz imaging of healthy pancreas (black lines) and PDAC (red lines) tissues freshly excised from mice: (**A**) unnormalized THz transmission spectra (blue line corresponds to the spectrum of and an empty experimental setup). (**B**) time-resolved, experimental impulse response. Insets show the absorption coefficient (**A**) and the dielectric permittivity (**B**) for PDAC and healthy tissues, respectively [3].



THz refractive index map of PDAC. (**A**) 5 mm thick Paraffin embedded PDAC tissue sample. (**B**) Terahertz refractive index map of (A) with each pixel size of 500 $\mu m \times 500\ \mu m$ (**C**) Histopathology image from a 5 μm sister-section of (A). The heterogeneous microenvironment is labeled in the histopathology image.

Summary

- We probe local changes in tissue's optical properties as novel imaging biomarkers to detect the immensely heterogeneous tumor microenvironment
- Our results demonstrate refractive index as a potent marker capable of resolving heterogeneity within *ex-vivo* murine PDAC samples.